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The influence of vegetation and landscape on the forest bird community of northeast Iowa

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The influence of vegetation and landscape on the forest bird community of northeast Iowa

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This dissertation is dedicated to my wife, Denise Ann Friedrick, for all of her love and support during this arduus but rewarding journey.

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ABSTRACT

I studied bird community dynamics and habitat associations of forest birds in northeast Iowa in 1995 and 1996. During this study, 107 different bird species were detected in northeast Iowa forests, including many neotropical migrant songbirds. However, a nest parasite, the brown-headed cowbird (*Molothrus ater*), was the most frequently detected bird during this study. The abundance and species richness of birds (both expressed as mean numbers per bird census point at each site) were both higher in 1995 but the rank orders of bird species in 1995 and 1996 were highly correlated, suggesting stable bird community structure over time.

Most previous investigations of bird-habitat relationships conducted in Midwestern forests have excluded recently logged/pastured habitats. In this study, we included forests varying widely in area (32-486 ha) and disturbance history (forest preserves, recently logged/pastured forests, etc.). We discovered that bird species considered to be of high management concern by the U.S. Fish and Wildlife Service have higher species richness (mean number of species per census point at each site) in undisturbed forests than in recently disturbed forests. Species richness of these birds was also higher in large forest tracts than in smaller forests patches.

Finally, we discovered that bird community composition shifts along a forest composition gradient, with many bird groups (e.g., neotropical migrants, USFWS high management concern species) tending to be more abundant and/or species rich in mesic forests. Most habitat associations were detected for only one year, demonstrating the need

for long-term studies to truly understand bird community dynamics and the strength of these associations.

CHAPTER 1. GENERAL INTRODUCTION

Neotropical migratory songbirds are species that breed in North America and migrate to the tropics of South and Central America to overwinter (Terborgh 1989). There has been great interest in the ecology of neotropical migrant songbirds in the past two decades, prompted in large part by published reports that some species are in significant population declines (Robbins et al. 1989, Peterjohn et al. 1995). Many theories have been proposed to explain these perceived declines, including the loss and fragmentation of habitat in both wintering and breeding grounds (Sherry and Holmes 1995). Forest fragmentation creates small forest patches that are unsuitable for many area-sensitive bird species (Galli et al. 1976, Faaborg et al. 1995). For instance, Burke and Nol (1998) found that within ovenbird (*Seirus aurocapillus*) territories, prey biomass was 10 to 36 times higher in large woodlots than in small woodlots. Furthermore, nest parasites and predators are often attracted to the edge habitat created during forest fragmentation and potentially reduce nest productivity of host species (Brittingham and Temple 1983, Wilcove 1985, Martin 1988, Robinson et al. 1995).

Other research has focused on issues of habitat suitability; i.e., how avian assemblage patterns are influenced by plant species composition (Holmes and Robinson 1981, Robinson and Holmes 1984), structural diversity (Karr 1971, Cody 1981) and successional stage (May 1982). Interestingly, habitat use by neotropical migrants appears to differ on wintering and breeding grounds. Most neotropical migrants are habitat generalists while overwintering in the tropics (Sherry and Holmes 1995), reaching their highest abundance in disturbed forest habitat (Petit et al. 1995). However, many neotropical migrants are specialized to breed in specific seral stages or floristic associations on breeding grounds in North America, including old-growth forests in some instances (Sherry and Holmes 1995).

Several studies have been conducted in Midwestern forests to document how landscape and habitat factors interact to influence bird communities at the local scale. For instance, patterns of avian species richness and abundance were discovered to be correlated with vegetation and landscape characteristics in Illinois (Blake and Karr, 1987) and Wisconsin (Ambuel and Temple, 1983) forests. Significantly, recently disturbed (logged, pastured) forests were excluded from the above investigations. There are several reasons, nevertheless, to support inclusion of disturbed habitats in studies which purport to document the habitat preferences of neotropical migrants in Midwestern landscapes. First, many neotropical migrant species are habitat specialists that prefer to breed in particular seral stages, including both second-growth and mature forests (Sherry and Holmes 1995). Second, recently disturbed forests make up the majority of forest cover in much of the Midwest, including northeast Iowa.

Research Goals

The primary goal of this research was to determine whether the composition of bird communities in northeast Iowa forests is influenced by the "natural quality" of forest vegetation. My colleagues and I define "naturalness" as the degree to which a given forest resembles (tree species composition, structural characteristics) that same forest in the absence of recent (50-75 yr) human impacts. Virtually all forests in Iowa have been disturbed within the past century (Raich et al. 1999) but some forests in this state (e.g., state forest preserves) have not been managed (i.e., logging, grazing) by humans for many years. Mature forest vegetation makes up a small proportion of the total forest cover in northeast Iowa, and it is logical to ask whether some bird groups (e.g., neotropical migrants) are most abundant and/or diverse in this scarce habitat type.

To answer the above questions, it was necessary to develop a "natural quality index" to quantify the degree of similarity between a given forest and other forests known to be "highly natural" (typically, state forest preserves). Such an index would allow us to directly test whether forest quality is related to patterns of bird community composition. The evaluation method presented in this dissertation is a multi-criteria system (Smith and Theberge 1986, 1987) that relies upon the scoring of six criteria (Tree Size, Tree Structure, Shrub Structure, Tree Dominance, Subcanopy Dominance, Shrub Dominance) based on explicit scoring rules. These rules were calibrated with respect to survey data gathered in state forest preserves and state parks which have not been logged or grazed for over 50 years. This method has the potential to be used by natural resource managers for natural quality evaluation of forest habitat as well as for prioritization of land acquisitions.

Another goal of this research was to determine the relative roles of landscape, forest structure and floristic composition in shaping bird communities in northeast Iowa forests. Although many ornithologists (e.g., MacArthur and MacArthur 1961) believe that avian habitat selection is influenced far more by foliage arrangement than by plant species composition, some bird species have been demonstrated to have particular tree species preferences while foraging (Holmes and Robinson 1981, Robinson and Holmes 1984). The influence of floristic composition on bird community structure question should be of particular interest to natural resource managers in the Midwest because many forests in this region are in transition from oak (*Quercus* sp.) to maple (*Acer* sp.) dominance due to recent fire suppression (Abrams 1992, Jungst et al. 1998).

A final goal of this research was to gather baseline data to document the composition of the northeast Iowa forest avifauna. Only two prior reports exist to describe this bird community (Bartsch 1897, Koenig 1979) but these are limited in both survey intensity and extent of geographic coverage. The bird census data gathered during this study will be valuable to future researchers who wish to analyze changes in the northeast Iowa avifauna relative to the current (i.e., 1990s) composition of this bird community.

Dissertation Organization

This dissertation is organized as papers to be submitted for publication in scientific journals. Chapters 2 and 3 deal primarily with the current composition of the forest avifauna in northeast Iowa forests. Although much of this material is duplicated in the two chapters, the intended audiences are different. Chapter 2 is a published (Hemesath and Norris 1998) paper geared towards Iowa birdwatchers and as such contains no statistical analyses. Comparisons are made with a published account of the avifauna in adjacent Wisconsin forests (Mossman and Hoffman 1989) and some discussion is devoted to perceived changes in the avifauna relative to a published account of this bird community (Bartsch 1897) from a century ago. For this paper, I compiled the bird census data for display in Table 1; furthermore, I wrote about half of the "Introduction", all of the section titled "Study Area" and about 80% of the descriptions of public birding areas. In Chapter 3, which has been submitted to the American Midland Naturalist, my co-authors and I analyze temporal variation in bird community composition at several different time scales. We also provide evidence to suggest that current saturation of northeast Iowa forests by brown-headed cowbirds (*Molothrus ater*) may have been induced by forest fragmentation following European settlement.

Chapter 4 is devoted almost entirely to the method developed to evaluate the natural quality of forest vegetation in northeast Iowa. This paper, co-authored by Don Farrar and myself, has been submitted for publication in Natural Areas Journal.

Chapter 5 is the linchpin of this dissertation. Here my colleagues and I present the results of analyses to determine whether bird assemblage patterns in northeast Iowa forests are related to the natural quality of forest vegetation as measured by the method described in Chapter 4. We plan to submit this paper to the Natural Areas Journal as a followup to the paper describing vegetation evaluation methodology.

Chapter 6 focuses on the relative influence of landscape and vegetation characteristics on bird community structure. We intend to submit this paper to the Journal of the Iowa Academy of Science. Finally, I present a summary of the major results of this research in Chapter 7.

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CHAPTER 2. FOREST AVIFAUNA OF NORTHEAST IOWA

A paper published in Iowa Birdlife

Lisa Hemesath and William Norris

Eighty-three (58%) of Iowa's 145 breeding bird species prefer forest or forest edge habitat (Best et al. 1996). Forty-one species, almost half of all forest-breeding birds and 28% of all Iowa's breeding birds, are neotropical migrants, birds that breed in North America and winter primarily south of the United States. According to several recent analyses of the Breeding Bird Survey data, some neotropical migratory bird species may be experiencing significant population declines (Robbins et al. 1989, Peterjohn et al. 1995, James et al. 1996). The decline of neotropical migrants has been associated with habitat loss and fragmentation on both the breeding and wintering grounds (Sherry and Holmes 1995).

Iowa possesses the most fragmented landscape of all 50 States, having lost over 99% of its prairies (Smith 1981), 89% of its wetlands (Dahl 1990), and over 75% of its original forests (Leatherberry et al. 1993). Because of intensive farming practices, restoration of lost forest habitat in Iowa is unlikely. Furthermore, many of the remaining forests have been altered by logging and/or cattle grazing. Therefore, the future of forest-dwelling birds in Iowa will depend on the quality of existing forest tracts and their careful management.

Land managers in Iowa want to incorporate the needs of neotropical migratory birds and other forest-dwelling birds in public area management plans, but wildlife professionals have yet to document suitable forest tracts for migrating and/or breeding purposes or formulate a management plan specific for forest birds. To gather information about the biodiversity of Iowa's forest ecosystem, a research project relating bird species diversity and abundance to landscape characteristics and vegetation type was conducted in 1995 and 1996 in northeast Iowa. The objectives of the study were to 1) conduct bird and floristic inventories of upland deciduous forests in northeast Iowa, 2) determine the importance of landscape and vegetation characteristics on bird usage of forest tracts, and 3) determine which species of forest-dwelling bird species can be feasibly managed in the fragmented forests of the agricultural midwest and, finally, 4) develop a mangement plan for those birds. Results of the bird inventories are presented in this paper.

STUDY AREA

Northeast Iowa is often referred to as "the Driftless Area" because the bedrock in this corner of the state was not plowed over with glacial debris during the Wisconsin and Illinoian epochs (Hallberg et al., 1984). Consequently, the landscape in this corner of the state is very rugged. A birdwatcher here can easily visit deep wooded canyons, broad floodplain forests and steep bluffs all in the same day.

A wide variety of forest types occur in northeast Iowa because of the topographic diversity. Dry uplands (ridgetops, west- and south-facing slopes) in northeast Iowa are usually dominated by oak species such as white oak (*Quercus alba*), bur oak (*Q. macrocarpa*), red oak (*Q. borealis*) and northern pin oak (*Q. ellipsoidalis*) in the canopy. Smaller amounts of shagbark hickory (*Carya ovata)*, black cherry (*Prunus serotina*), white ash (*Fraxinum americana*), sugar maple (*Acer saccharum*) and basswood (*Tilia americana*) often occur as sub-dominant canopy trees in these forests, while sugar maple and ironwood (*Ostrya virginiana*) are the most abundant subcanopy trees.

A different forest type is typically found on cool north- and east-facing slopes. Sugar maple, red oak and American basswood (*Tilia americana*) are the usual overstory dominants here, often accompanied by yellowbud hickory (*Carya cordiformis*), black ash (*Fraxinus nigra*) and red elm (*Ulmus rubra*). Common subcanopy trees include sugar maple, ironwood, and musclewood (*Carpinus caroliniana*).

The floodplain forests that straddle the streams and rivers in northeast Iowa are not easily characterized. A frequently inundated site is likely to have cottonwood (*Populus deltoides*), willow (*Salix* spp.), silver maple (*Acer saccharinum*), and/or boxelder (*Acer negundo*) as dominant trees in the overstory, because these tree species have good dispersal capabilities and rapid growth rates. River terraces elevated above a stream or river are likely to have slower growing black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), black ash (*Fraxinus nigra*), elm (*Ulmus americana, U. rubra*), basswood, yellowbud hickory and/or bur oak as dominants in the canopy, especially if flooding is infrequent.

The above descriptions refer to forests that have not been recently impacted by human activity, however, undisturbed tracts of timber are rare in northeast Iowa. Many forests are currently grazed by cattle and/or selectively cut for valuable timber trees. Such forests often have dense thickets of prickly shrubs such as gooseberry (*Ribes missouriense*), prickly ash (*Zanthoxylum americanum),* multiflora rose (*Rosa multiflora*) and bramble (*Rubus allegheniensis, R. occidentalis*) growing in their understories. These shrubby "blooms" are uncharacteristic of forests long withheld from these land-use practices (e.g., Backbone State Park, White Pine Hollow State Preserve).

Fire repression can also be considered as a human disturbance because it interferes with presumed nature fire regimes (Abrams, 1992). Although the effects of fire repression are perhaps not as obvious as those of logging and/or grazing practices, the implications are potentially just as dramatic. It has been predicted by many researchers that sugar maple will replace oak species as the dominant tree in many Midwest forests in the next century because oaks are dependent on fire for regeneration (Abrams, 1992).

METHODS

Forty-six forest tracts subjected to various levels of disturbance and ranging in size from 80 to 1300 acres were censused for birds in 1995 and 1996. Twenty-nine forest tracts were predominately private land holdings; the remaining were public holdings owned by the state or county. Protocol for censusuing birds followed Ralph et al. (1993). One hundred ninety-seven point count stations were established in the chosen forest tracts and censused three times during the breeding season at two-week intervals between late May and early July. The number of census points was proportional to the size of the forest tract; larger forest tracts contained more census points. Locations of the point count stations were determined by using a stratified random sampling scheme. All stations were placed in upland habitat–ridges, slopes, ravines, and along small "trout" streams. No points were located in the Mississippi floodplain. In order to eliminate the possibility of counting the same bird at two or more stations, all census points were situated no closer than 250 meters apart. Census points were visited from sunrise to 10:00 a.m. on calm, rainless mornings. Point counts were 10 minutes in duration with birds observations recorded in three separate time intervals: 0-3 minutes, minutes 4-5, and 5-10 minutes. Birds seen or heard within a 50 meter radius at a point count station were recorded and used to determine relative abundance. All birds detected beyond 50m during point counts and between point count stations were also recorded and included in a site's species richness list.

RESULTS AND DISCUSSION

Published studies on the avifauna of northeast Iowa are limited to a turn of the century census along the Upper Iowa River (Bartsch 1897) and the Allamakee County Foray (Koenig 1979). Both studies report a species list with associated estimates of relative abundance. The species list resulting from the foray and this study were similar in regards to forest birds. However, the species list generated by Bartsch (1897) does bear some differences to Koenig (1979) and our data (Table 1). Bartsch (1897) reported several species as abundant that were absent or found in lesser numbers on subsequent studies [i.e., Sharp-shinned Hawk, Least Flycatcher (ranked #40 in this study), Black-and-white Warbler, and Cerulean Warbler (#36)]. Conversely, three species in the top 25 most frequently observed birds (Table 1) [Blue-gray Gnatcatcher (#2), Northern Cardinal (#11), and Eastern Titmouse (#25)] were not found by Bartsch (1897). These birds have obviously expanded their ranges northward during the 20th century. The Pileated Woodpecker (#37) was also not observed by Bartsch (1897). According to Koenig (1897), Anderson (1907) claims that this species was not abundant in Iowa at the turn of the century.

The species richness of the 46 forest tracts surveyed ranged from a high of 61 species to a low of 27 species. According to Best et al. (1996) nearly half of Iowa's breeding bird species (69 of 145 species) are consistently or primarily area-sensitive. Of the 107 bird species documented in this study (Table 1), including breeding birds and probable migrants, 36% (38 species) are area-sensitive. Approximately 46 % (26 species) of the 56 neotropical migratory bird species detected are area-sensitive.

Even with highly fragmented forests, some of Iowa's public and privately owned lands are still attracting such area-sensitive species as the Pileated Woodpecker, Least and Acadian Flycatchers, Wood Thrush, Louisiana Waterthrush, American Redstart, and Cerulean Warbler. Whether area-sensitive birds are successfully breeding in the forests of northeast Iowa is unknown at this point; our study did not monitor bird nests. However, according to studies conducted in the fragmented forests of central Illinois (Robinson 1988, Wilcove and Robinson 1990), reproductive success was extremely low due to high levels of nest parasitism (>60% of all nests) and nest predation (>75% of all open-cup nests). A more recent study (Robinson 1992) found even higher nest predation (80%) and brood parasitism rates (76%) in the same study area. While some of the forest tracts we surveyed were considerably larger than the Illinois woodlands, which ranged from 30 to 160 acres, effects of fragmentation were obvious due to the ubiquitous nature of the Brown-headed Cowbird; the cowbird was the most abundant species detected, found in even our largest forest tracts (Table 1). It may be that the fragmented forests of northeast Iowa act as population "sinks" (Pulliam 1988, Brawn and Robinson 1996), habitat in which reproduction is insufficient to balance local mortality. Research is currently being conducted in the Driftess Area of Iowa, Wisconsin, and Minnesota on the nesting success of forest-dwelling bird species (pers. comm. Melinda Knutson, Biological Resources Division of the U.S. Geological Service). Results of this study will determine if woodlands of the Driftless Area are ecological "sinks" for some of our forest-breeding bird species.

Upland forests of northeastern Iowa and southern Wisconsin have very similar avian communities. Of the 20 most abundant species found in Iowa's woodlands, only three differed from Wisconsin's top 20 (Mossman 1989) (Table 1). These differences are probably the result of the sampling scheme; Iowa censused both private and public lands that frequently contained small streams and floodplains; Wisconsin's bird list was the result of surveying only upland habitat on public lands. Private land holdings and recently purchased public lands are frequently "patchy" in character and contain a mosaic of secondary-growth woodlands, young woodlands, forest openings (e.g. tree-fall gaps, small clearcuts, etc.), and forest-edge habitat. These disturbed habitats, in conjunction with streamside habitat, may explain the presence of the House Wren, American Redstart, and Yellow-throated Vireo on the Iowa list. The two species found on the Wisconsin list and not appearing on Iowa's top 20 list include the Northern Flicker (#45) and Great-horned Owl (not detected because censusing was restricted to mornings only).

Not surprisingly, some of the best birding in northeast Iowa can be found on our larger forest tracts. Table 1 lists the top eight public lands with the highest species richness. The following site descriptions for these birding "hot spots" will help birders locate specific species of interest.

<u>Backbone State Park</u> (Delaware County)

Backbone State Park (1780 ac.) is the oldest member of Iowa's state park system (1920). The forests here have not been logged or grazed for over 75 years; hence, mature oak (red and white) and sugar maple forests with open understories occur throughout much of Backbone. Such forests are conspicuous along the West Lake Trail, which extends for four miles connecting the modern and primitive campgrounds. Mature floodplain forests dominated by black walnut, hackberry, black ash, and elm accompany the Maquoketa River as it winds through the park to provide additional bird habitat. White pine groves, red cedar glades, and prairie remnants also occur here. More bird species were recorded from Backbone State Park during the two years of this study than at any other site.

The outstanding songbird at Backbone State Park is, without a doubt, the Veery. In the summer these birds are vocal all along the road connecting the north entrance of the park to the central "flats" area. A Veery nest with eggs was discovered at Backbone in late June, 1994. Louisiana Waterthrush, Acadian Flycatcher, Cerulean Warbler, and both cuckoo species also occur here during the breeding season, and Northern Parulas were heard singing in bottomland forests near the "flats" area of Backbone in 1996 and 1997.

Finally, a Red-shouldered Hawk nest with three fledglings was discovered in a wooded ravine in June, 1994. This sighting represents one of the only nest records for this hawk species inland from the Mississippi River in Iowa.

White Pine Hollow State Preserve (Dubuque County)

The majority of White Pine Hollow (812 ac.) came into the state preserve system in 1935, 1936, and 1937, though additional portions were acquired by the state as recently as 1992. This rugged property, perhaps the most unfragmented upland forest in the state, features mature oak and maple woods, deep canyons, babbling streams, and waterfalls as well as the largest natural stands of white pine in the state. Uncommon neotropical migrant songbirds such as Acadian Flycatcher, Least Flycatcher, Veery, Louisiana Waterthrush, Kentucky Warbler, and Cerulean Warbler were consistently seen at White Pine Hollow during the summers of 1994, 1995, and 1996.

More unusual songbirds were observed at White Pine Hollow than at any other site during this study. Of these, sightings of Canada Warblers during the summers of 1994 (1 bird) and 1995 (2-3 birds) were probably the most outstanding. These birds rarely ventured far from a north-facing algific talus slope overlooking a deep canyon about a mile due north of the south parking lot. In 1995, these birds were present as late as early August. Due to the fragile nature of algific talus slopes, no attempt was made to locate a nest. **Future visitors to White Pine Hollow are likewise asked to stay off these slopes, which are usually open, rocky, and covered with thickets of Canada Yew. Algific talus slopes are home to many rare plant species and the federally endangered Iowa Pleistocene Snail** *(Discus macclintocki)*, **organisms that could be detrimentally impacted by trampling.**

Other unusual summer bird sightings at White Pine Hollow during this study include a Worm-eating Warbler (1994), Black-throated Green Warbler (1995) and Winter Wren (1996). Significantly, a Cerulean Warbler was seen feeding a cowbird chick deep in the interior of White Pine Hollow in 1994. This serves as additional evidence that no northeast Iowa forest is immune to cowbird parasitism.

<u>Ram Hollow - Hoffman Wildlife Management Area (WMA)</u> (Delaware County)

The Turkey River effectively divides Ram Hollow-Hoffman WMA (480 ac.) into two units and also renders much of the property inaccessibile. The western half was obtained in 1974 and the larger eastern half was purchased in 1985. Many portions of this relatively intact forest have obviously been either grazed and/or selectively logged in the past twenty years. Nonetheless, one can find small groves of white pine (*Pinus strobus*) on ridgetops throughout this state-owned property.

The summer avifauna of Ram Hollow-Hoffman includes such birds as the Acadian Flycatcher, Louisiana Waterthrush, and Cerulean Warbler. A Black-throated Green Warbler was heard singing here during the breeding season of 1996. The meadows adjacent to the parking area always contain Willow Flycatchers, Yellow Warblers, and Common Yellowthroats in the summer, and a wide bend in the Turkey River near the parking area is the site of a Bank Swallow colony.

Together, Ram Hollow - Hoffman and White Pine Hollow form one of the largest contiguous forest tracts in all of northeast Iowa. This entire forest region may be one of the few "source" areas for breeding songbirds in this region of the state.

Bloody Run Creek WMA (Clayton County)

Known as a good trout fishing stream, Bloody Run Creek and its surrounding uplands were purchased in 1977 and 1989. This 526-acre forest tract is fragmented by a railroad that winds its way through the southern and western portions of the site. Abandoned pastures in the lowlands, old farm roads, and abandoned cropfields on the ridges further fragment the forest.

Due to its fragmented character, Bloody Run Creek WMA is a great place to view bird species that prefer edge habitat. Yellow Warblers can reliably be seen in the east parking lot and Chestnut-sided Warblers have been heard singing occassionally in shrubby edges throughout the tract. The only White-eyed Vireo detected during this study was also found here.

Maintained hiking trails are nonexistent at Bloody Run Creek. The only available trail is a foot path that leads west out of the east parking lot and parallels the creek to the north on a somewhat steep slope. For the sure-footed, this path may lead to more area-sensitive species such as the Louisiana Waterthrush, Wood Thrush, and Acadian Flycatcher.

Paint Creek Unit, Yellow River Forest (Allamakee County)

Although portions of this forest have been acquired from 1936 through 1990, the bulk of the property came into state ownership in 1936 and 1937. Much of this forest has been logged since acquisition, including several recent clear-cuttings. Planted pine trees occur along the main paved road through Paint Creek as well as in even-aged stands adjacent to more primitive trails. Thus, the property is really a mosaic of forest patches of various sizes surrounded by open land and access roads rather than an intact forest with a substantial core area. The resulting associated avifauna is a mix of forest-interior and forest-edge species.

Blue-winged Warblers, a forest-edge species (Best et al. 1996), were reliably observed in trailside shrubs about one mile north of the forest headquarters in both 1995 and 1996 (note: trail begins behind an A-frame building just west of the forest headquarters and continues uphill through a pine plantation, *not* the trail that begins behind the forest headquarters). A Hooded Warbler, a forest-interior species (Herkert et al. 1993), was observed in wooded ravines and young deciduous forest along this same trail in both 1995 and 1996 (beyond the opening frequented by Blue-winged Warblers). Cerulean Warblers, Kentucky Warblers, and Acadian Flycatchers, all birds highly to moderately sensitive to forest fragmentation (Herkert et al. 1993), were also regularly seen in the forest just behind the state forest headquarters. Yellow-bellied Sapsuckers, another area-sensitive species (Best et al. 1996), were observed nesting in young second-growth forest further back on this same trail in 1995 and 1996.

Fish Farm Mounds WMA (Allamakee County)

Fish Farm Mounds WMA (576 ac.) occurs near the mouth of the Upper Iowa River between New Albin and Lansing. The very sandy substrate of an old river terrace supports several very rare (for Iowa) stands of black oak with blueberry, huckleberry, and clubmoss in the ground layer. More oak forests (mostly red oak) occur on the surrounding slopes, mixed with occasional goat prairies on west and south exposures. Paper birch is a common tree at Fish Farm Mounds, which perhaps explains why Yellow-bellied Sapsuckers are so common here.

A Worm-eating Warbler was observed at Fish Farm Mounds through most of June 1996. Chestnut-sided Warblers were also observed here infrequently at the edge of the main parking lot.

Clear Creek WMA (Allamakee County)

Clear Creek WMA (438 ac.) was purchased in three separate parcels in 1990, 1992, and 1996. The majority of the forests have been selectively logged in recent years and, consequently, are open and shrubby. The tract is situated on very steep slopes overlooking wet meadows and pastureland. The flat uplands above these slopes have been converted to cropfields.

In addition to the typical forest songbirds, Orchard Orioles and nesting Yellow-bellied Sapsuckers were observed at Clear Creek during the two years of this study.

Iverson Bottoms Wildlife Management Area (Allamakee County)

Acquired in 1988, Iverson Bottoms (338 ac.) lies along the west bank of the Upper Iowa River. The forest consists mostly of secondary-growth woods on ridges and steep slopes.

The tract's best stand of timber can be seen on an old logging road, now accessible by foot only, that parallels the river and runs south from the riverside parking lot (note: one needs to walk up east facing slope to intersect logging road). Due to the path's proximity to the river, Warbling Vireos and Cerulean Warblers are occassionally observed.

Shrubby habitat borders the tract along the gravel road to the north and in a large east-west ravine where an old farmstead use to reside. Brown Thrashers, Gray Catbirds, and Blue-winged Warblers are found frequently in these areas.

Iowa plays host to 70 species of neotropical migratory birds that rely on mature or young deciduous forests or shrubby habitat for breeding or migrating purposes. According to our study, 107 species of birds, including 56 species of neotropical migratory birds, use the forests and forest edges of northeast Iowa during migration and the breeding season. Documentating the avifauna in Iowa's forests is only the first step toward devising an adequate bird conservation and forest ecosystem management plan. Future analysis of our data will relate the importance of vegetation structure and diversity and landscape characteristics on bird usage of Iowa's diverse forest resources.

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Table 1. Total number of observations within 50-meter point count stations for 1995 and 1996 in 46 forest tracts in northeast Iowa, and the species lists for the eight public land tracts with the highest species richness. An "x" indicates a species was observed within the boundaries of a point count station in the designated forest tract; an "o" signifies that a species was only observed outside the point count station or while traveling between stations. BACK = Backbone State Park; RAM = Ram Hollow-Hoffman Wildlife Management Area; CLEAR = Clear Creek Wildlife Management Area; WPH = White Pine Hollow State Preserve; BLOOD = Bloody Run Wildlife Management Area; IVER = Iverson Bottoms Wildlife Management Area; PAINT = Paint Creek Unit of Yellow River Forest; FISH = Fish Farm Mounds Wildlife Management Area.

Rank	NM[1]	WI Top 20[2]	Species	Total No. of Obs.	BACK	RAM	CLEAR	WPH	BLOOD	IVER	PAINT	FISH
1		X	Brown-headed Cowbird	664	x	x	x	x	x	x	x	x
2	N	X	Blue-gray Gnatcatcher	587	x	x	x	x	x	x	x	x
3	N	X	Eastern Wood-Pewee	507	x	x	x	x	x	x	x	x
4	N	X	Red-eyed Vireo	505	x	x	x	x	x	x	x	x
5	N		American Redstart	395	x	x	x	x	x	x	x	o
6	N		House Wren	341	x	x	x	x	x	x	x	o
7	N	X	Ovenbird	324	x	x	x	x	x	x	x	x
8	N	X	Indigo Bunting	318	x	x	x	x	x	x	x	x
9		X	White-breasted Nuthatch	301	x	x	x	x	x	x	x	x
10	N	X	Great Crested Flycatcher	270	x	x	x	x	x	x	x	x
11		X	Northern Cardinal	263	x	x	x	x	x	x	x	x
12		X	Blue Jay	259	x	x	x	x	o	x	x	x
13	N	X	Gray Catbird	251	x	x	x		x	x	x	x
14		X	Black-capped Chickadee	216	x	x	x	x	x	x	x	x
15		X	Red-bellied Woodpecker	196	x	x	x	x	x	x	x	x
16		X X	Hairy/Downy Woodpecker	172	x	x	x	x	x	x	x	x
17	N	X	Rose-breasted Grosbeak	169	x	x	x	x	x	x	x	x
18	N		Yellow-throated Vireo	168	x	x	x	x	x	x	x	x
19	N	X	Scarlet Tanager	162	x	x	x	x	x	x	x	x
20		X	American Robin	152	x	x	x	x	x	x	x	o
21			American Goldfinch	148	x	x	x	x	x	x	x	x
22	N		Acadian Flycatcher	129	x	x		x	x	x	x	

Table 1. (continued)

Rank	NM[1]	WI Top 20[2]	Species	Total No. of Obs.	BACK	RAM	CLEAR	WPH	BLOOD	IVER	PAINT	FISH
23			Rufous-sided Towhee	123		x	x	o	x	x	x	x
24	N		Northern Oriole	103	x	x	x	o	x	x	x	x
25			Tufted Titmouse	100	x	x	x	x	x	x	x	x
26			American Crow	74	x	x	x	x	o	x	o	x
27	N		Wood Thrush	74	x	x	x	x	x		x	x
28	N		Chipping Sparrow	69	x	o	x	x	o	o	x	
29	N		Common Yellowthroat	55	x	o	o	o	x	x	x	o
30			Red-winged Blackbird	52	x	x	x	x	x	o	o	o
31	N		Yellow Warbler	47	o	x	x	x	x	x	x	x
32			Yellow-bellied Sapsucker	40		x	x		o	o	x	x
33	N		Blue-winged Warbler	39		o	o		x	x	x	x
34			Song Sparrow	37	o	x	o	o	o	x	x	o
35	N		Cerulean Warbler	36	o	x		x	o	x	x	o
36	N		Ruby-throated Hummingbird	36	x	x	o	x	o	x	x	o
37			Pileated Woodpecker	32	x	x	x	x		x	o	o
38			Red-headed Woodpecker	32	x	x		x		o		x
39			Common Grackle	28	x		x			o	o	x
40	N		Least Flycatcher	27	o	x	o	x	o	o		
41			Field sparrow	23	o	x	x		o	o	o	o
42	N		Warbling Vireo	23	x	o	o	x	x	x	o	o
43			Eastern Phoebe	22	x	o	o	x	x	x	o	
43	N		Yellow-billed Cuckoo	22	x	x	x	x	o		o	o
45			Cedar Waxwing	21	x	o	x	x			o	x
45			Wild Turkey	21	x	x	o	o	o	x	o	o
47		X	Northern Flicker	19	x	x	o		o	x		
48	N		Louisiana Waterthrush	17	x	o		x	x	x		
48	N		Veery	17	x			x	o			o
50			Red-tailed Hawk	14	o		x		o	x	x	

Table 1. (continued)

		WI Top		Total No.	BACK	RAM	CLEAR	WPH	BLOOD	IVER	PAINT	FISH
Rank	NM[1]	20[2]	Species	of Obs.								
51			Northern Rough-winged Swallow	13	x		o		o			
52			Brown Thrasher	12	o	o	x			o		o
52	N		Chestnut-sided Warbler	12		o			x		o	o
54			Mourning Dove	11		x	o	x	o	o	o	o
55	N		Tennessee Warbler	6				x				
56			Barred Owl	5	x	o		o				
56			Eastern Bluebird	5	o		x					
56	N		Eastern Kingbird	5			x					
59	N		Alder Flycatcher	4								
60	N		Hooded Warbler	3							x	
60	N		Black-billed Cuckoo	3	x	o		o		o	o	
60	N		Kentucky Warbler	3	o			o			x	
60	N		Northern Parula	3	o			x				
60	N		Willow Flycatcher	3		x	o		x			
60			Wood Duck	3								
66			Belted Kingfisher	2		o			o	o		
66			Brown Creeper	2								o
66			European Starling	2								
66			Great Blue Heron	2	o			x				
66			Ruffed Grouse	2	o					o		o
66			Winter Wren	2				o				
72	N		Barn Swallow	1	x		o					
72	N		Black-throated Green Warbler	1		o		o				x
72	N		Broad-winged Hawk	1								
72	N		Canada Warbler	1				o				
72			Cooper's Hawk	1				o				
72			Killdeer	1	o					o		o

Table 1. (continued)

		WI Top		Total No.	BACK	RAM	CLEAR	WPH	BLOOD	IVER	PAINT	FISH
Rank	NM[1]	20[2]	Species	of Obs.								
72	N		Prothonotary Warbler	1								
72	N		Whip-poor-will	1								
72	N		White-eyed Vireo	1					x			
72			White-throated Sparrow	1			x					
72	N		Worm-eating Warbler	1		o		o				o
72	N		Yellow-bellied Flycatcher	1							x	
84	N		Bank Swallow	0			o					
84	N		Bell's Vireo	0								
84	N		Bobolink	0								
84			Canada Goose	0								
84			Carolina Wren	0								
84	N		Chimney Swift	0								
84	N		Common Nighthawk	0								
84			Common Snipe	0					o			
84	N		Dickcissel	0			o					
84			Eastern Meadowlark	0								
84	N		Golden-winged Warbler	0								
84	N		Grasshopper Sparrow	0						o		
84			Great Egret	0								
84		X	Great-horned Owl	0								
84			House Sparrow	0								
84			Mallard	0	o							
84	N		Orchard Oriole	0			o					
84			Red-shouldered Hawk	0	o							
84			Ring-necked Pheasant	0	o		o	o	o	o		
84			Savannah Sparrow	0								
84			Sedge Wren	0		o						

Table 1. (continued)

Rank	NM[1]	WI Top 20[2]	Species	Total No. of Obs.	BACK	RAM	CLEAR	WPH	BLOOD	IVER	PAINT	FISH
84			Swamp Sparrow	0							o	
84			Turkey Vulture	0		o						
84			Vesper Sparrow	0		o						
			Total No. of Species[3]	107	61	59	57	56	54	54	52	51

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[1]NM=neotropical migrant, (N) denotes a species is a neotropical migrant
[2]Wisconsin's top 20 most abundant bird species in the upland forests of southern Wisconsin (Mossman and Hoffman 1989)

CHAPTER 3: HOW VARIABLE IS BIRD COMMUNITY STRUCTURE IN NORTHEAST IOWA FORESTS?

A paper submitted to American Midland Naturalist

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Abstract-A study of the forest bird community in Iowa's highly fragmented northeast corner was undertaken in 1995 and 1996 in forests varying widely in size (32-486 ha) and degree of recent human impact (grazed, logged, undisturbed). Birds were censused using standard point-count protocol. When bird species were ranked by total observations, the brown-headed cowbird (*Molothrus ater*) ranked first followed by seven neotropical migrant bird species (both years). The species richness and abundance of birds were both greater in 1995 than 1996 but the rank order of bird species was highly correlated ($\tau = 0.715$) between years, suggesting stable community structure. The rank orders of bird species in large (> 162 ha) and small (< 82 ha) forest patches were highly correlated (1995: $\tau = 0.703$; 1996: $\tau = 0.728$), suggesting that patch size has little influence on overall bird community structure in this landscape. Few relationships were detected between total forest area (measured at three different spatial scales) and either the abundance or species richness (mean number detected per bird census point at each study site) of birds (grouped into migratory assemblages). Furthermore, we detected no effect of forest area on brown-headed cowbird abundance. Comparisons with historical accounts were hampered by different survey methodology (1979) and the qualitative nature of data (1897). Nonetheless, we conclude that the current saturation of northeast Iowa forests by brown-headed cowbirds may be a recent phenomenon, induced by forest reduction and fragmentation in this region since European settlement.

INTRODUCTION

Bird community dynamics in fragmented landscapes of the agricultural Midwest have received much recent attention. Studies of forest bird communities in Wisconsin (Ambuel and Temple, 1983), Illinois (Blake and Karr, 1987) and Missouri (Hayden *et al.*, 1987) have demonstrated that avian species diversity and abundance patterns are often influenced by forest patch size. Much evidence suggests that reduction and fragmentation of Midwestern forests have greatly impacted forest bird communities. For example, the density of "area sensitive" bird species may be depressed in severely fragmented landscapes where large forest patches are scarce or absent (Faaborg et al., 1995). Conversely, the current saturation of southern Illinois forests by brown-headed cowbirds (*Molothrus ater*) is probably a recent phenomenon induced by drastic forest reduction and fragmentation (Robinson *et al.*, 1993).

In this paper, we explore variability in bird community structure in another forested landscape of the Midwest: northeast Iowa. Although approximately 59% of northeast Iowa supported trees (sometimes mixed with prairie grass) at the time of settlement, only 19% of this landscape is currently forested (Figs. 1a, 1b). We know of only two historic accounts that describe the forest avifauna of this region. Bartsch (1897) published a list of bird species based on his field notes taken during a canoe trip along the Upper Iowa River (Allamakee and Winneshiek counties) in 1895. In this report, Bartsch gives a qualitative abundance estimate for the majority of listed bird species. More recently, Koenig (1979) published a bird list for northeast Iowa based on nine breeding bird surveys conducted within Allamakee County in 1978. These surveys were 25 miles long and patterned after those conducted by the U.S. Fish and Wildlife Service (Robbins *et al.*, 1986). The total number of observations recorded for each species during the surveys is given in Koenig's report.

Given the results of previous work in adjacent states, we suspect that forest loss and fragmentation in northeast Iowa have had a significant impact on the forest avifauna in that region. Therefore, one goal of our research was to analyze levels of variability in this bird community over time. First, we analyzed our own bird census data (collected in 1995 and 1996) for annual levels of variation in rank order of bird species, abundance and species richness. Then, we compared our data with the two published accounts (Bartsch, 1897; Koenig, 1978) of this same bird community to examine long-term change in community composition.

A second goal of our research was to examine the influence of forest area on bird community structure in northeast Iowa. To do this, we first measured the correlation between the rank order of bird species in large (> 162 ha) and small (< 82 ha) forest patches. Then, we tested for the influence of forest cover on avian abundance and species richness. For the latter analyses, we measured total forest cover within the actual site boundaries as well as within 1 km and 5 km extensions of the site boundaries to test for scale dependence of relationships (Wiens *et al.*, 1987; Wiens, 1989; Freemark *et al.*, 1995).

In this paper, the term 'bird' refers collectively to cuckoos, hummingbirds, passerines and woodpeckers. A complete list of bird species encountered during field work for this study can be found in Hemesath and Norris (1998).

STUDY AREA

The northeast Iowa landscape is very rugged and characterized by exposed bedrock and great topographic diversity (Prior, 1991). High bluffs, steep slopes, broad floodplains and narrow trout streams all occur in this corner of the state. Northeast Iowa forests are primarily oak-dominated and belong to the Central Hardwoods (Braun, 1964). The forest vegetation in this region has been described in detail by Cahayla-Wynne and Glenn-Lewin (1978) and Pusateri *et al.* (1993).

METHODS

FOREST SITE SELECTION

We selected 46 forest sites ranging in area from 32 to 486 ha in northeast Iowa (Allamakee, Clayton, Delaware, Dubuque, Fayette and Winneshiek counties) for inclusion in this study. Of these, 17 were public lands that encompassed several state parks and forest preserves and many wildlife management areas. The 29 privately owned sites included forests that had recently been subjected to recent logging and/or cattle grazing as well as others set aside for many years as forest reserves. Most previous studies (Ambuel and Temple, 1983; Blake and Karr, 1987) excluded recently disturbed forests; nonetheless, we included them because they comprise the majority of forest cover in northeast Iowa. However, we did not include study sites from the Mississippi River floodplain because the avifauna of this forested landscape has already been studied (Knutson *et al.*, 1996; Knutson and Klaas, 1997).

Although our original intention was to select study sites which were "patches" isolated on all sides from other timber, this was impossible because virtually all forests in northeast Iowa are connected to other forest land by at least a narrow corridor of trees. Hence, our study sites were not isolated "patches" in the strict sense of Hanski and Simberloff (1997). Nevertheless, most of our study sites were surrounded by cropfields or open pasture along the majority (> 80%) of their borders.

We allocated bird census points to each study site in proportion to area using a stratified random sampling scheme. Our smallest site had two bird census points; the largest site had twelve such points. A variety of topographic positions were sampled in these study sites, ranging from upland habitat - ridgetops, slopes and ravines - to lowland floodplains and narrow wooded creek bottoms. The center of each bird census point was always a tree marked with two parallel bands of white paint and pink flagging. The center of each census point was placed at least 50 m from the forest edge so that the entire point (50 m radius) would be within the forest. Census points were situated at least 250 m apart to minimize the possibility of double counting individual birds during a census (Ralph *et al.* 1993).

FIELD WORK

We conducted bird censuses between May 30 and July 15 in 1995 and 1996. All field technicians received two weeks of training in bird identification immediately prior to conducting these censuses. Protocol for censusing birds followed Ralph *et al.* (1993). Censuses took place on calm, rainless mornings from sunrise to 10:00 AM. We censused each bird census point (197 in all) three times each season at approximately two week intervals; each census within a given year was conducted by a different observer to minimize observer bias. Point counts were 10 minutes in duration. We recorded all birds detected during the census as occurring either inside or outside a 50 m radius circle centered on the marked tree.

We thoroughly surveyed the vegetation at each site to allow for analysis of habitat relationships; however, these results will be reported in a future paper (Norris *et al.*, ms.).

ANALYSES FOR TEMPORAL VARIATION IN BIRD COMMUNITY STRUCTURE

Construction of Rank Order Curves.-We constructed rank abundance curves to allow visual inspection of avian community composition and rank order (separately for 1995 and 1996). To do this, we plotted the total number of observations for each bird species versus its rank. The "total observations" for each bird species was defined to be the sum of all detections of that species recorded within the 50 m radius circle (to minimize detectability bias) at all sites during all point counts (including data from all three census replicates) in a given year. All raptors, nightjars, late spring vagrants and flyovers were omitted from these (and all subsequent) analyses, as were birds recorded as 'flyovers' during point counts.

Annual Variation in Abundance, Species Richness and Rank Order.-We tested for annual variation in avian abundance (n = 46 sites) using paired t-tests. We conducted these analyses separately for i) all birds, ii) neotropical migrants, iii) permanent residents and iv) short distance migrants (migratory status for all birds as given in Best *et al.*, 1996). To provide the data needed for the t-tests, we calculated the total number of bird detections inside the 50 m radius circle (during three census replicates) per census point in a given season. Then, we calculated the mean number of detections per point for each site (separately for 1995 and 1996). Finally, we compared the mean point abundance for each site between years using a paired t-test. As a separate test for annual variation in abundance, we performed a sign test, with continuity correction (Sprent, 1993), to test for decreasing trend in total observations among bird species (n = 49 bird species) between 1995 and 1996.

We tested for annual variation in species richness of birds (n = 46 sites) using paired t-tests. We conducted these analyses separately for i) all birds, ii) neotropical migrants, iii) permanent residents and v) short distance migrants. To provide the data for these t-tests, we calculated the total number of bird species detected per census point during three census replicates (no distance restriction) in a given season. Then, we calculated the mean number of bird species detected per point for each site (separately for 1995 and 1996). Finally, we compared the mean point richness for each site between years using a paired t-test.

We compared the rank order of bird species (based on abundance) between years using Kendall's tau rank correlation coefficient (τ) (Sprent, 1993). We chose this statistic because it has a provision for handling ties. Mid-ranks were assigned to bird species tied in rank for a given year. In order to minimize the occurrence of ties between infrequently detected birds, we excluded bird species detected fewer than ten times in each of 1995 and 1996 from this analysis (and all subsequent analyses of rank order).

Long-Term Variation in Species Composition.-We ranked the bird species recorded during the 1978 Allamakee County census (Koenig, 1979) by total observations to allow comparison with the 1995 and 1996 rankings using Kendall's tau rank correlation coefficient (τ). Upon discovering a large discrepancy in the two data sets due to the high abundance of red-winged blackbirds (*Agelaius phoeniceus*), common grackles (*Quiscalus quiscula*) and American crows (*Corvus brachyrhynchos*) in Koenig's study, we repeated the comparison after deleting these three species from all lists.

To compare the current forest bird community with that described a century ago, we present Bartsch's qualitative descriptions of abundance (1897) for each species adjacent to our own data to allow visual comparison and we provide a summary of these differences in the results section.

ANALYSES FOR SPATIAL VARIATION IN BIRD COMMUNITY STRUCTURE

Characterization of Total Forest Cover.-We measured the forest cover centered on each study site at three different spatial scales. First, we measured the actual forest cover within the boundaries of each study site, marked on recent (post-1980) 7.5 series USGS quadrangles, using a planimeter. It is our impression, after comparison of actual forest cover with that represented on these maps during several low altitude flights, that the accuracy of forest cover representation on these maps is at least 90%.

We also measured the total amount of forest area within 1 km and 5 km, respectively, of the boundary of each site. This allowed us to analyze for spatial variation in bird-area relationships. To do this, we first created a digital GIS coverage of site boundaries from the above topographic maps. From this site coverage, we created two buffer coverages (1 km, 5 km) which we subsequently used to clip a land-use GIS coverage classified from recent (1992) 30-m resolution Thematic Mapper (TM) satellite imagery. Finally, we used FRAGSTATS software (McGarigal and Marks, 1994) to calculate the total amount of forest cover within 1 km and 5 km, respectively, of the boundaries of each site from the clipped land-use coverages.

Rank Correlation Analysis of Birds in Large versus Small Sites.-We compared the rank order of bird species (based on abundance) in large (> 162 ha, $n_L = 11$) versus small (<

82 ha, $n_S = 23$) forest patches (separately for 1995 and 1996) using Kendall's rank correlation coefficient (τ). We selected these size cutoffs by visual inspection so that categories would be disjunct while at the same time have approximately equal representation of total bird detections. As specified by these cutoffs, 12 out of 46 study sites were excluded from these analyses.

Upon discovering brown-headed cowbirds to be highly ranked in both small and large sites, we tested for a linear relationship between cowbird abundance and forest area using simple regression analysis (separately for 1995 and 1996).

Analysis for Spatial Variation in Bird-Area Relationships.-We used multiple regression analysis to test for the response of avian abundance and species richness to total forest area at three spatial scales: i) actual site boundaries; ii) 1 km-buffer of each site; iii) 5 km-buffer of each site. We conducted these analyses separately for i) all birds, ii) neotropical migrants, iii) permanent residents and v) short distance migrants; avian species richness and abundance (mean values per point at each site) were calculated as described above.

RESULTS

Community Composition and Rank Order.-A small number of bird species were detected much more frequently than all the others in both 1995 (Fig. 2) and 1996. The brown-headed cowbird was the most frequently detected bird in both years (Table 1). The blue-gray gnatcatcher (*Polioptila caerulea*), eastern wood-pewee (*Contopus virens*), red-eyed vireo (*Vireo olivaceus*), American redstart (*Setophaga ruticilla*), house wren (*Troglodytes aedon*), indigo bunting (*Passerina cyanea*) and white-breasted nuthatch (*Sitta carolinensis*) were also among the top ten ranked birds for both years. Eight of the top ten ranked birds in 1995 (and seven of the top ten ranked birds in 1996) were neotropical migrants.

TEMPORAL VARIATION IN BIRD COMMUNITY STRUCTURE

Annual Variation in Abundance, Species Richness and Rank Order.-The species richness and abundance of i) all birds, ii) neotropical migrants and iii) permanent residents were higher in 1995 than in 1996 (Table 2). This trend even extended to the abundance of individual bird species ($Z = 3.43$, $p < .001$); 37 of 49 bird species were observed more frequently in 1995 than in 1996.

The rank order of bird species was similar in 1995 and 1996 ($\tau = 0.715$, $p < .001$). Nine bird species (17.6 %) shifted in rank at least ten places between years; of these, the tufted titmouse (*Baeolophus bicolor*), red-winged blackbird, least flycatcher (*Empidonax minimus*), yellow-billed cuckoo (*Coccyzus americanus*), and northern rough-winged swallow (*Stelgidopteryx serripennis*) moved up at least ten ranks from 1995 to 1996, while the American goldfinch (*Carduelis tristis*), ruby-throated hummingbird (*Archilochus colubris*), yellow-bellied sapsucker (*Sphyracius varius*) and cedar waxwing (*Bombycilla cedrorum*) all dropped at least ten rank positions in the same time interval.

Long-Term Variation in Bird Community Composition.-The three most frequently observed bird species in Koenig's (1978) census were the red-winged blackbird, common grackle and American crow. None of these species are currently abundant in northeast Iowa forests during late spring and summer (Table 1). Bird species listed by Koenig as being uncommon or rare include the yellow-bellied sapsucker, least flycatcher (*Empidonax minimus*), veery (*Catharus fuscescens*), cerulean warbler (*Dendroica cerulea*), Louisiana waterthrush (*Seiurus motacilla*), Kentucky warbler (*Oporornis formosa*), hooded warbler (*Wilsonia citrina*) and orchard oriole (*Icterus spurius*). These results concur with our own (Table 2; Hemesath and Norris, 1998).

The rank order determined from the 1978 data is quite different from that revealed from our data. Values for Kendall's τ were .203 ($p < .05$) and .137 ($p < .10$) for comparisons with the 1995 and 1996 rankings, respectively. We suspected that these results were strongly affected by the high ranking of red-winged blackbird, common grackle and American crow in Koenig's data, and therefore recalculated Kendall's τ after removing these three bird species from the data sets. However, these deletions did not dramatically improve the correlation between the rankings ($\tau = .216$, $p < .05$ for 1995 versus 1978; $\tau = .267$, $p < .05$ for 1996 versus 1978).

Bartsch (1897) described the majority (76 %) of the 49 forest bird species included in our analyses as "abundant", "common" or "met with everywhere" in 1895. Among "abundant" birds was the cerulean warbler, a species currently believed to be in significant decline (Robbins *et al.*, 1992). The black-and-white warbler (*Mniotilta varia*) is listed as being "common in wooded areas" in 1895; this species was not encountered by us during the summers of 1995 and 1996.

Rare species in 1895, as perceived by Bartsch, were the yellow-bellied sapsucker, red-bellied woodpecker (*Melanerpes carolinus*), northern rough-winged swallow, warbling vireo (*Vireo gilvus*), yellow-throated vireo (*Vireo flavifrons*), blue-winged warbler (*Vermivora pinus*) and Baltimore oriole (*Icterus galbula*). These bird species are currently uncommon to rare by our standards (Table 1). Significantly, neither the northern cardinal (*Cardinalis*

cardinalis) nor the blue-gray gnatcatcher were listed as occuring in northeast Iowa in 1895; these were among the most abundant bird species detected by us in the 1990s. Nor was the tufted titmouse (*Baeolophus bicolor*), a bird species found by us to be of intermediate rank abundance in the 1990s (Table 1).

SPATIAL VARIATION IN BIRD COMMUNITY STRUCTURE

Effect of Patch Size on Rank Order of Birds.-The rank orders of bird species in large versus small forest sites were highly correlated in 1995 ($\tau = 0.703$, $p < .001$) and 1996 ($\tau = 0.728$, $p < .001$). The brown-headed cowbird was the most frequently observed bird in small sites both years and in large sites in 1995; it ranked second in large sites in 1996. Furthermore, we detected no relationship between cowbird abundance and forest area at any spatial scale (Table 3). Looking beyond cowbirds in the rankings, eight of the top ten most frequently detected birds in large sites were neotropical migrants in 1995 (as were seven of the top ten in 1996) (Table 1). Of the ten most frequently observed birds in small sites, six species in 1995 and seven species in 1996 were neotropical migrants (Table 1).

Spatial Variation in Bird-Area Relationships.-We discovered that total forest cover has occasional influence on the abundance and species richness of northeast Iowa forest birds (Table 3). Only permanent resident abundance (1995) and neotropical migrant species richness (1996) were influenced by forest area within site boundaries. Likewise, total bird abundance (1995) and neotropical migrant species richness (1996) were related to forest area within 1 km of site boundaries. At the 5 km scale, total bird abundance, neotropical migrant abundance (-), total bird species richness (1996) and short-distance migrant species richness

(1996) were correlated with total forest area. None of the above relationships were detected during both years of this study (Table 3).

DISCUSSION

Short-Term Variation in Community Composition.-The general pattern of abundance illustrated in Fig. 2 is a familiar one (Magurran, 1988), with the majority of species represented by a relatively small number of individuals and a few species being very abundant. This same pattern of abundance has also been demonstrated for the forest bird communities in the western Great Lakes region (Howe *et al.*, 1996) and the Adirondacks (Webb *et al.*, 1977). The dominant bird species were similar during both years of our study, with eight bird species being in the top ten in both 1995 (Fig. 2, Table 1) and 1996 (not shown). Of the birds which shifted in rank at least ten places among years, the American goldfinch was the only species that ever occurred among the top twenty for a given year (1996). All of the other bird species whose ranks shifted dramatically between 1995 and 1996 never achieved a rank above twenty. Thus, we conclude that the rank order of birds in northeast Iowa forests was stable during the two years of this study.

Nevertheless, we detected an overall decline in abundance and species richness of forest birds between 1995 and 1996. Likewise, the abundance of most individual bird species declined between those years. There are many potential underlying causes of this annual variation which include variable food supply, predation events, weather and/or winter mortality (Holmes, 1990). Another possible reason for these differences is observer bias between years. However, we believe that this latter explanation is unlikely because of low field technician turnover between the two field seasons of this study. We believe that the observed differences in abundance and species richness of birds between years were real; we are, however, unable to pinpoint the underlying cause(s) given only two years of data. Our detection of this significant annual variation supports the separate analyses of 1995 and 1996 data in all future analyses of habitat relationships because habitat use can be variable on an annual basis (Schooley, 1994).

Long-Term Variation in Community Composition.-The three most frequently detected birds in the 1978 survey were the red-winged blackbird, common grackle and American crow (Table 2); none of these three species occured in the top 20 during either 1995 or 1996 in our study (Table 2). All of the above bird species often occur in large congregations in open areas (Jackson *et al.*, 1996), habitats that were not included in our study. Nonetheless, most of the birds listed by Koenig as occurring in northeast Iowa are the same as those detected by us in forests. Among these are the brown-headed cowbird, which was the fourth most frequently encountered bird in Koenig's report.

The lack of concordance in rank structure with Koenig's data can be explained by the differing methodologies used in the two studies. The 1978 census was conducted using breeding bird survey (BBS) methodology in which observers record all birds detected at regular intervals along a road (Robbins *et al.*, 1986). Thus, this methodology samples field and edge habitat in addition to forest habitat, whereas our study took place entirely within the boundaries of 46 forested study sites. Furthermore, since no provision is made for variable detectability of bird species in the BBS methodology; loud birds will be detected more frequently than plaintive species. In our study, we only included birds detected within a 50 m radius circle to minimize detectability bias.

Our findings do concur with Koenig (1979) on the relative rarity of several bird species, including several wood warblers, tyrant flycatchers, thrushes and woodpeckers. These results are no surprise because most of these species are at the edge of their distribution in the eastern United States. For example, the Louisiana waterthrush, blue-winged warbler, Kentucky warbler and hooded warbler are southern species near the northern boundary of their breeding distribution, and the sapsucker, least flycatcher and veery are northern species at the southern reaches of their respective breeding ranges (Peterson, 1980). Many organisms have been documented to have declining abundance at the periphery of their distributions (Brown, 1984), thus explaining these mutual results.

Bartsch described most birds in northeast Iowa as being frequent to abundant in his 1897 report (Table 1); this differs from our perception of the current bird community (Fig. 2). Given the anecdotal nature of Bartsch's report, as well as its limited geographical extent (Upper Iowa River valley), it is difficult to make meaningful comparisons with our data.

Effect of Patch Size on Bird Community Structure.-Conventional wisdom suggests that the composition of bird assemblages in small and large forest patches should not be identical (Blake and Karr, 1984; Blake, 1991). For instance, many Iowa bird species (including many neotropical migrants) are area sensitive (Best *et al.*, 1996) and hence less likely to occur in small forest patches. Furthermore, many permanent resident and short-distance migrants are known to prefer forest openings and edge habitat (Whitcomb *et al.*, 1993) which are commonly associated with small forest patches. However, our discovery that the rank orders of bird species detected in large and small forest sites are highly correlated suggests that forest area does not strongly influence overall composition of this avifauna. Furthermore, avian abundance and species richness are not strongly related to forest area at the spatial scales we considered; the few relationships we did detect were not consistent between years (Table 3).

There are several possible reasons for this apparent lack of influence by total forest area on bird community structure in northeast Iowa. First, it may be that the abundance and species richness of forest birds are more strongly influenced by characteristics other than "forest area." These might include habitat features such as vegetation, soil and topographic characteristics (Blake and Karr, 1987), and/or landscape characteristics such as amount of core area, patch shape, adjacent land-use and degree of isolation from other forest patches (Freemark *et al*, 1995). For example, Blake and Karr (1987) reported that forest area was correlated with the abundance of one-third to one-half of bird species examined in Illinois woodlots, but that the abundances of more than half (66-72%) of these bird species were influenced by habitat variables.

Another possible explanation for our results is that within each bird group analyzed, the response of each species to patch size is so variable that forest area is weakly linked, at best, to the abundance and species richness of our chosen bird groups. Among bird species grouped together as 'neotropical migrants' are birds documented to exhibit positive area sensitivity (e.g., Acadian flycatcher, cerulean warbler) as well as other species (e.g., indigo bunting, chipping sparrow) reported in some studies to exhibit negative area sensitivity (Best et al., 1996). Our inconclusive results regarding the influence of forest area on the abundance and species richness of these birds may thus be an artifact of our decision to conduct analyses on birds grouped into migratory assemblages.

Probable impact of forest fragmentation on the northeast Iowa forest avifauna.- Bartsch (1897) described cowbirds as "common" in northeast Iowa in the 1890's; nonetheless, it is impossible to determine how common they actually were relative to other bird species present at the time. Brown-headed cowbirds are believed to have been confined to the short-grass prairie region of the United States prior to European settlement, where they fed in areas of short grass and bare ground and likely used scattered trees for nest searching and display perches (Brittingham and Temple, 1983). At that time, cowbirds may have been absent from the large forest expanses that covered eastern North America since these lacked the open areas needed for feeding. Indeed, cowbird density and nest parasitism rates are currently low in regions of the Midwest where forest cover is extensive, such as the Missouri Ozarks and the northwoods of Minnesota and Wisconsin (Robinson *et al.*, 1995, 1995b; Donovan *et al.*, 1995). However, as forest was cleared for farming, this newly created open land allowed cowbirds to expand their range eastward (Brittingham and Temple, 1983; Robinson *et al.*, 1993, 1995b). The above scenerio may likewise describe a general pattern of cowbird invasion into northeast Iowa forests given the large-scale forest reduction and fragmentation that have occurred in this region (Fig. 1a, 1b).

Nest parasitism by brown-headed cowbirds has been implicated as a major cause of the perceived decline of neotropical migrant birds (Ambuel and Temple, 1983; Brittingham and Temple, 1983; Robinson *et al.*, 1993; Robinson *et al.*, 1995a, 1995b). Of the 48 most frequently detected birds during our study (excluding cowbirds), 46% are known to be frequent or regular cowbird hosts (Best *et al.*, 1996). Given the high densities of brown-headed cowbirds in northeast Iowa forests, many of these host species may be population "sinks" (Pulliam, 1987; Donovan *et al.*, 1996) which do not produce enough offspring to offset annual mortality. Current research sponsored by the U.S. Fish and Wildlife Service is attempting to determine levels of cowbird parasitism and breeding success of resident birds in upland forests of the Paleozoic Plateau, including northeast Iowa (Knutson, pers. comm).

CONCLUSIONS

The past 150 years have seen much of northeast Iowa's historic tree cover reduced to fragments. We believe that current saturation of northeast Iowa forests by brown-headed cowbirds may be due to this forest fragmentation; however, this is a tentative conclusion due to the qualitative nature of available historic data. The quantitative data that we provide here and elsewhere (Hemesath and Norris, 1998) describing the current forest avifauna of northeast Iowa should be a valuable baseline for future researchers analyzing changes relative to the 1990s.

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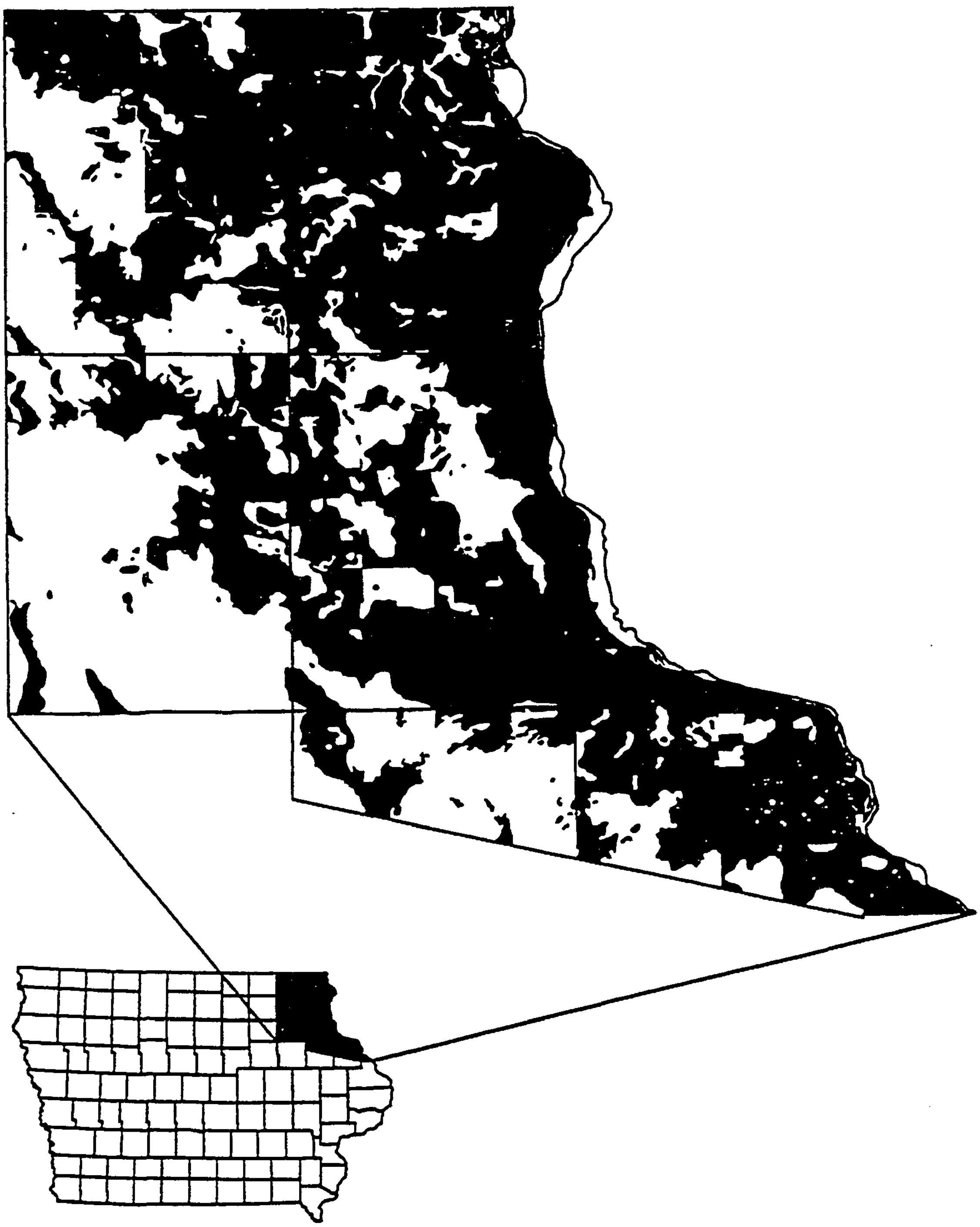

Fig. 1a. Extent of tree cover in northeast Iowa at the time of settlement (1832-1859). The shaded region (59%) represents areas in northeast Iowa reported to be moderately to densely covered by trees by Government Land Office surveyers (data summarized by Anderson (1996)).

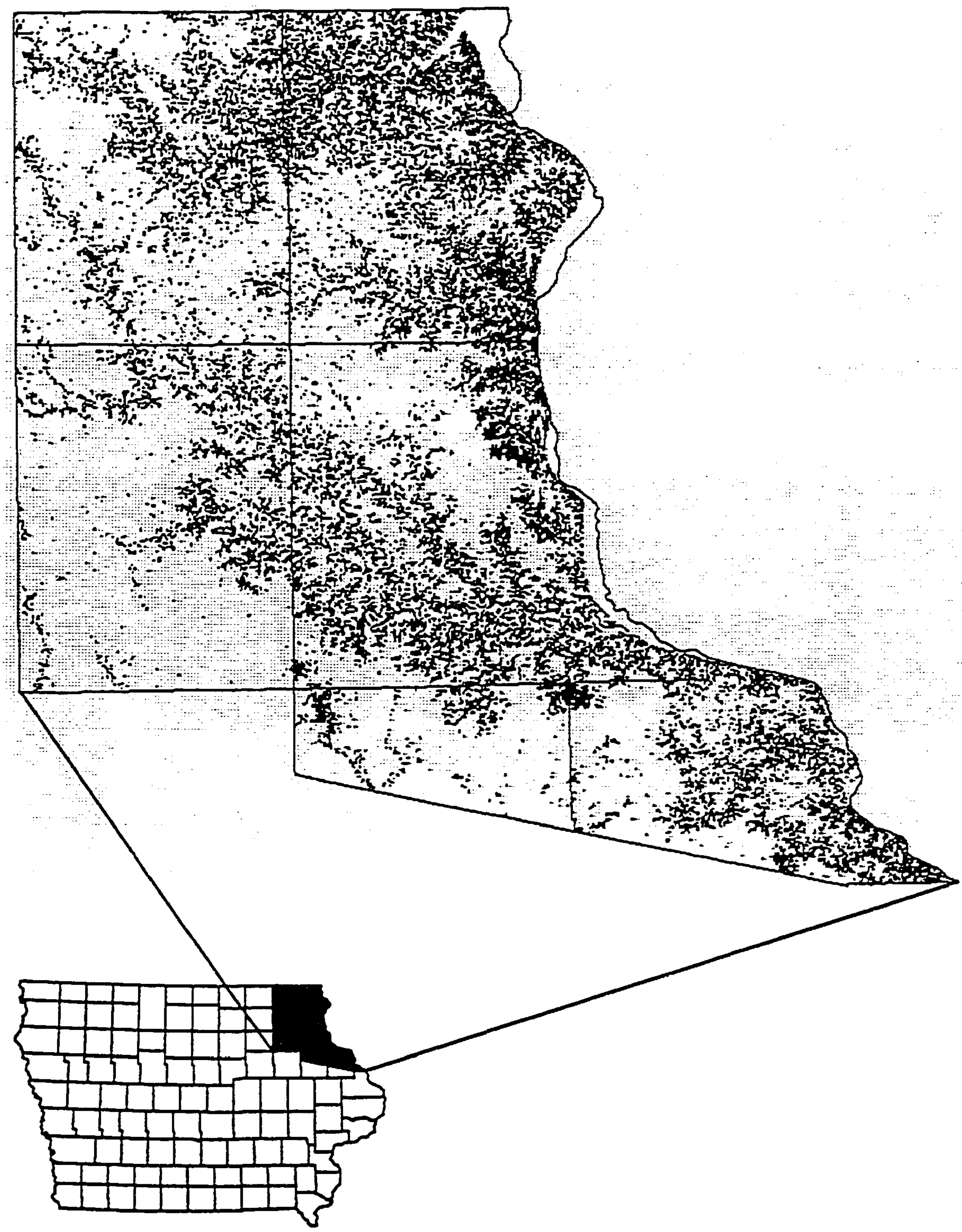

Fig. 1b. Current extent of tree cover in northeast Iowa (1992). Total tree cover (19%) was calculated from a GIS raster coverage of landuse types classified from recent (1992) thematic mapper satellite imagery (30-m resolution).

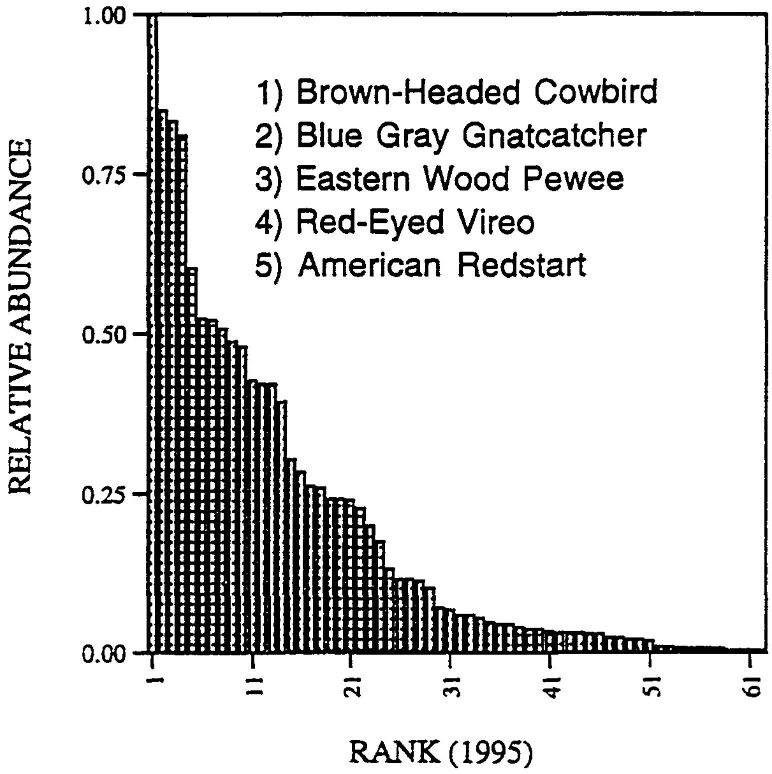

Fig. 2. Rank order of bird species detected during point census counts (inside 50 m radius circle) in northeast Iowa forests (1995). Relative abundance = total detections of each species divided by total detections of the brown-headed cowbird.

Table 1.-Rank order of songbirds based on total number of individuals detected inside a 50 m radius circle during point count censuses of 46 forest sites in northeast Iowa (1995, 1996). Tied species are assigned midranks within a given category. T95, T96 are based on observations from all sites; L95, L96 are based on observations from large sites with area > 162 ha, as are S95 and S96 for observations from small sites < 82 ha in area. K = Koenig (1979) data (ranked); B = Bartsch (1897) data (a= abundant, c = common, f = frequent, un = uncommon, r = rare, x = not present, ( ) = abundance class inferred from text, * = (unable to determine).

	T95	T96	S95	L95	S96	L96	B	K
Brown-headed cowbird, *Molothrus ater*	1	1	1	1	1	2	c	4
Blue gray gnatcatcher, *Polioptila caerulea*	2	2	3	2	3	1	x	34
Eastern wood pewee, *Contopus virens*	3	4	2	5	2	5.5	a	18
Red-eyed vireo, *Vireo olivaceus*	4	3	4	4	4	3	c	39
American redstart, *Setophaga ruticilla*	5	5	12	3	9.5	4	a	35.5
House wren, *Troglodytes aedon*	6	6	6.5	9	6	7	c	7
Indigo bunting, *Passerina cyanea*	7	8	9.5	7	5	8	c	9
White-breasted nuthatch, *Sitta carolinensis*	8	9	11	10	8	9	a	28.5
Great crested flycatcher, *Myiarchus crinitus*	9	15	9.5	8	13	18.5	f	21
Ovenbird, *Seiurus aurocapillus*	10	7	14.5	6	9.5	5.5	c,a	35.5
Gray catbird, *Dumetella carolinensis*	11	14	13	20	17	18.5	c	11
Northern cardinal, *Cardinalis cardinalis*	12.5	10	5	23	11	12	x	5
Blue jay, *Cyanocitta cristata*	12.5	11	8	13	12	12	(c)	14
Red-bellied woodpecker, *Melanerpes carolinus*	14	22	6.5	14.5	22	21	uc	20
Black-capped chickadee, *Poecile atricapillus*	15	12	14.5	16	7	18.5	a	27
Rose-breasted grosbeak, *Pheucticus ludovicianus*	16	19	16	18	15.5	22	c	13
Yellow-throated vireo, *Vireo flavifrons*	17	17	19	12	24	15	(uc)	30.5
Scarlet tanager, *Piranga olivacea*	18	18	24.5	19	18	14	c	30.5
American robin, *Turdus migratorius*	19.5	20	23	17	19	18.5	c	8
Hairy/downy woodpecker, *Picoides villosus/pubescens*	19.5	16	17	22	15.5	12	c	33
Tufted titmouse, *Baeolophus bicolor*	21	38	18	14.5	31.5	41	x	25
Acadian flycatcher, *Empidonax virescens*	22	23	21	11	30	16	c	43

Table 1 (continued).

	T95	T96	S95	L95	S96	L96	B	K
Baltimore oriole, *Icterus galbula*	23	27	20	24.5	26	24	(uc)	17
Eastern towhee, *Pipilio erythrophthalmus*	24	21	22	28	22	28.5	c	26
American goldfinch, *Carduelis tristis*	25	13	26	24.5	14	10	c	16
Red-winged blackbird, *Agelaius phoeniceus*	26.5	42	38	21	41	36.5	a	1
Wood thrush, *Hylocichla mustelina*	26.5	25.5	28.5	26	26	23	c	42
American crow, *Corvus brachyrhynchos*	28	24	27	29	28.5	26.5	c	3
Chipping sparrow, *Spizella passerina*	29	25.5	24.5	30	20	33.5	c	22
Common yellowthroat, *Geothlypis trichas*	30	28.5	28.5	35	26	28.5	a	12
Yellow warbler, *Dendroica petechia*	31	32	45	27	35.5	25	c	24
Song sparrow, *Melospiza melodia*	32.5	36	32.5	37	33.5	44	(a)	6
Least flycatcher, *Empidonax minimus*	32.5	45.5	30.5	35	48	44	c	46
Pileated woodpecker, *Dryocopus pileatus*	34	40	32.5	33	37.5	41	x	38
Yellow-billed cuckoo, *Coccyzus americanus*	35	47	34	32	45	44	c	32
Eastern phoebe, *Sayornis phoebe*	36.5	45.5	38	35	41	48.5	a	37
Cerulean warbler, *Dendroica cerulea*	36.5	35	45	31	48	26.5	a	46
Blue-winged warbler, *Vermivora pinus*	38	31	45	39.5	37.5	30.5	r	40
Common grackle, *Quiscalus quiscula*	39.5	38	38	43	41	33.5	c	2
Louisiana waterthrush, *Seiurus motacilla*	39.5	48	35	39.5	45	46	c	48.5
No. rough-winged swallow, *Stelgidopteryx serripennis*	41	49	30.5	48.5	48	48.5	r	19
Field Sparrow, *Spizella pusilla*	43	41	38	39.5	41	41	c	10
Red-headed woodpecker, *Melanerpes erythrocephalus*	43	33.5	41.5	45	35.5	30.5	c	15
Northern Flicker, *Colaptes auratus*	43	44	41.5	43	41	47	a	23
Ruby-throated hummingbird, *Archilochus colubris*	45.5	30	45	43	28.5	33.5	c	46
Yellow-bellied sapsucker, *Sphyrapicus varius*	45.5	28.5	45	46.5	22	36.5	r	48.5
Warbling vireo, *Vireo gilvus*	47	38	38	46.5	33.5	38.5	(uc)	28.5
Veery, *Catharus fuscescens*	48	43	48.5	39.5	45	33.5	*	44
Cedar waxwing *Bombycilla cedrorum*	49	33.5	48.5	48.5	31.5	38.5	c	41

Table 2.-Comparison of A) abundance and B) species richness of birds in northeast Iowa forests between 1995 and 1996. Abundance (detections inside 50 m radius circle) and species richness (no distance restriction) were determined at each census point over three census replicates and then averaged for each forest site (separately for 1995, 1996). Paired t-tests were used to compare these mean values for each site in 1995 and 1996. $\overline{X}$ = estimate of mean; SE = standard error of the estimate; T = value of Student's T statistic for paired t-test (n = 46 study sites).

A) Abundance

	1995		1996		Difference (1995-1996)			
	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	$\lvert T \rvert$	$p > \lvert T \rvert$
All Birds	22.6	0.83	17.1	0.62	5.5	0.87	6.3	< 0.01
Neo. Migr.	13.8	0.60	10.4	0.47	3.5	0.52	6.6	< 0.01
Perm. Resid.	5.3	0.37	3.4	0.25	1.9	0.37	5.3	< 0.01
Sho.-Dist. Migr.	3.4	0.25	3.4	0.23	0.0	0.22	0.2	0.83

B) Species Richness

	1995		1996		Difference (1995-1996)			
	$\overline{X}$	SE	$\overline{X}$	SE	$\overline{X}$	SE	$\lvert T \rvert$	$p > \lvert T \rvert$
All Birds	20.3	0.40	19.2	0.33	1.1	0.37	2.9	<0.01
Neo. Migr.	10.6	0.27	9.8	0.27	0.8	0.24	3.2	<0.01
Perm. Resid.	5.8	0.17	5.4	0.15	0.4	0.18	2.4	0.02
Sho.-Dist. Migr.	3.9	0.23	4.0	0.18	-0.2	0.15	1.0	0.33

Table 3-Simple linear regression analyses of A) abundance and B) species richness of birds on forest cover measured at three spatial scales. "Area" = area of forest cover within boundaries of study site (n = 46 study sites); "Buffer-1 km" = area of forest cover within 1 km extension of study site boundaries; "Buffer -5 km" = area of forest cover within 5 km extension of study site boundaries. Numbers represent probabilities associated with linear regression models for each test. '*' indicates $p \leq 0.05$; '**' indicates $p \leq 0.01$.

A) Abundance

	Area	Buffer -1 km	Buffer - 5 km
Total Birds (1995)	0.11	0.05*	0.05*
Total Birds (1996)	0.29	0.91	0.58
Neotropical Migrants (1995)	0.41	0.14	0.02(-)*
Neotropical Migrants (1996)	0.19	0.78	0.78
Permanent Residents (1995)	0.01*	0.06	0.78
Permanent Residents (1996)	0.70	0.45	0.29
Short-Distance Migrants (1995)	0.82	0.89	0.54
Short-Distance Migrants (1996)	0.55	0.93	0.84
Brown-Headed Cowbirds (1995)	0.64	0.57	0.63
Brown-Headed Cowbirds (1996)	0.34	0.72	0.85

B) Species Richness

	Area	Buffer -1 km	Buffer - 5 km
Total Birds (1995)	0.95	0.42	0.50
Total Birds (1996)	0.19	0.07	0.02*
Neotropical Migrants (1995)	0.49	0.42	0.32
Neotropical Migrants (1996)	0.05*	0.01**	0.14
Permanent Residents (1995)	0.55	0.93	0.45
Permanent Residents (1996)	0.65	0.36	0.37
Short-Distance Migrants (1995)	0.69	0.62	0.08
Short-Distance Migrants (1996)	0.40	0.72	< 0.01**

CHAPTER 4. A METHOD FOR THE NATURAL QUALITY EVALUATION OF CENTRAL HARDWOOD FORESTS IN THE UPPER MIDWEST

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ABSTRACT

In this paper we present a multi-criteria method for the natural quality evaluation of hardwood forests in the Upper Midwest. We define *natural quality* as the condition (maturity, structural diversity, dominance patterns) of a forest relative to that same forest in the absence of recent (50 to 75 yr) major anthropogenic disturbance (timber harvest, pasturing, etc.). Our method relies upon survey of woody vegetation in 0.10 ha circular plots, during which the surveyor measures the dbh of the largest trees in the plot; records the total percent cover of the canopy, subcanopy and shrub layers; and lists all the woody species present in each of these forest strata within broad cover classes. These data are then used to score six evaluation criteria (Tree Size, Tree Structure, Shrub Structure, Canopy Dominance, Subcanopy Dominance, Shrub Dominance) following explicit rules calibrated with respect to survey data from forest preserves. These scores are summed to yield a natural quality index (Q) which ranges in value from 0 to 20. A measure of the overall natural quality of a forest can be determined by computing the mean of these quality indices.

Index terms: natural area evaluation, forests, priority ranking, Iowa, Midwest

INTRODUCTION

The goal of natural quality evaluation is "to identify the most ecologically valuable natural areas so planning and management practices can be applied so as to maintain the areas' values" (Smith and Theberge 1987). Applications of natural area evaluation include nature reserve selection (Margules et al. 1991), decision making in urban planning and development (Tubbs and Blackwood 1971, Norris and Farrar 1999) and assessment of wildlife habitat suitability (Usher 1985). An extensive literature exists for both theoretical and practical aspects of this topic (summarized in Margules and Usher 1981; Smith and Theberge 1986, 1987; Spellerberg 1983).

Conservation Evaluation in the Midwest

In the Midwestern United States, three general approaches to conservation evaluation have been used. One approach, "floristic quality assessment", is a quantitative method based on plant species diversity that was developed for evaluation of natural areas in the vicinity of Chicago, Illinois (Swink and Wilhelm 1994). For application of this method, each native vascular plant in the Chicago flora has been assigned a numerical "coefficient of conservation" (C) value between 0 and 10 that is based on its relative abundance in the region as well as its relative fidelity to strict synecological conditions. After surveying the flora of a particular area, the floristic quality index (I) is calculated as follows:

$$I = \overline{C}\,\sqrt{N}$$

where $\overline{C}$ is the mean C value and N is the number of plant species observed. This method has recently been modified for use in evaluation of natural areas in Michigan (Herman et al. 1997).

"Intuitive" methods for conservation evaluation of natural areas have been widely used in the Midwest. Intuitive methods do not require that the evaluator collect survey data in any systematic fashion. Rather, the evaluator assigns one of these grades to a natural area of interest based on inspection of aerial photographs and his/her impressions during one or more visits to the site.

Intuitive methods were first described by White (1978) for evaluation of natural areas in Illinois. In this system, five grades of natural area quality are defined that reflect the successional stage and the degree of disturbance observed for a particular vegetation community:

Grade A: Relatively stable or undisturbed communities

Grade B: Late successional or lightly disturbed communities

Grade C: Mid-successional or moderately to heavily disturbed communities

Grade D: Early successional or severely disturbed communities

Grade E: Very early successional or severely disturbed communities

More recently, the Minnesota Natural Heritage Program has developed ranking guidelines (unpublished) that are specific to different natural area types. In this approach, separate descriptions are provided for A (excellent), through D (poor) rankings of over 40 plant communities (e.g., "Oak Forest," "Maple-Basswood Forest," "Lowland Hardwood Forest," etc.). Evaluation of a site takes place following inspection of aerial photographs and/or informal ground survey.

Finally, Tans (1974) proposed a multi-criteria method for evaluation of natural areas in Wisconsin. In this model, points are allocated within four main categories: biological features, physical features, degree of threat and availability. Within the biological features category, various subcategories are delineated (i.e., quality, commonness, community diversity, size and buffer) and scored separately. The scores from each of these five subcategories are summed to yield a quality index for biological features; this value and scores for the other three main categories (physical features, degree of threat and availability) can then be compared among natural areas to accomodate priority ranking. Similarly, we developed a multi-criteria system for evaluation of forests in Ames, Iowa (Norris and Farrar in press) that derives from Tans' conceptual framework.

A Multi-Criteria Method for Evaluation of Central Hardwood Forests of Iowa

A large-scale survey of forests in northeast Iowa (six county region) was initiated in 1994 to accomodate several research and conservation goals. The research objective was to investigate how various forest management practices impact forest songbird communities in northeast Iowa (Hemesath and Norris 1998). Additionally, a major funder of this research (The Nature Conservancy, Iowa Chapter) wished to develop a data base of information for northeast Iowa forests to help them prioritize future acquisitions.

To meet these objectives, we developed methods for both rapid survey and natural quality evaluation of woody vegetation in forests of northeast Iowa. The survey method is a modified releve system (Mueller-Dombois and Ellenberg 1974) designed for survey of 0.10 ha circular plots. The evaluation method is a multi-criteria system which relies upon scoring six criteria from the survey data. The scores from these criteria are summed to yield a natural quality index (Q) for each plot ranging in value from 0 to 20. These indices can be aggregated in a variety of ways to summarize the overall quality of a forest.

In this paper, we present the conceptual framework of the survey and evaluation methods, describe their implementation, discuss them with reference to current theory

(Margules and Usher 1981, 1984, Smith and Theberge 1986, 1987) and compare them with other methodologies. We believe that our methodology offers conservationists and land managers a new and ecologically complete option for evaluation of hardwood forests in the Upper Midwest.

THE STUDY AREA

Although Iowa is more famous for its historic prairies, the northeast corner of this state (often referred to as the Paleozoic Plateau) was predominantly forested (60% forest cover) in the middle of the last century (Anderson 1996). However, logging and conversion of forested lands to agricultural purposes have reduced this historic tree cover to a patchwork of forest remnants (current forest cover: 18%). Northeast Iowa forests belong to the Central Hardwoods (Braun 1964) and have been described by Cahayla-Wynne and Glenn-Lewin (1978). Oak (*Quercus alba* L., *Q. ellipsoidalis* E.J. Hill, *Q. macrocarpa* Michx. and *Q. rubra* L.), maple (*A. saccharum* Marsh.) and American basswood (*Tilia americana* L.) are the typical canopy dominants of forests on ridgetops and sloping terrain in this region, and black walnut (*Juglans nigra* L.), hackberry (*Celtis occidentalis* L.) and elm (*Ulmus americana* L., *U. rubra* Muhl.) are usually dominant in the canopy of floodplain forests.

A small number of forests in northeast Iowa (state preserves, state parks, forest reserves) have been protected for many years and retain a high degree of natural integrity. These forests are usually characterized by closed canopies, diffuse shrub layers and high native plant diversity. However, the majority of the forests in northeast Iowa have been grazed and/or logged within the past two decades. These practices alter forest structure and composition in several ways. First, vertical stratification in recently disturbed forests is often reduced such that canopy and subcanopy layers are poorly differentiated. Second, the shrub layer (0.5 - 2.0 m) in these forests is often choked with prickly shrub species such as gooseberry (*Ribes missouriense* Nutt. ex T. & G.), prickly ash (*Zanthoxylum americanum* P. Miller), multiflora rose (*Rosa multiflora* Thunb. ex Murray), barberry (*Berberis* L. sp.), blackberry (*Rubus allegheniensis* Porter ex Bailey) and black raspberry (*R. occidentalis* L.). These shrubby "blooms" are uncharacteristic of forests which have been withheld from grazing and logging for many years. The above distinctions between mature and recently disturbed forests are the basis of our evaluation methodology.

METHODS

Survey Methodology

Our survey methodology is presented in Fig. 1. We designed it for use in circular (area: 0.1 ha; radius: 18 m) plots. Plots of this size permit simultaneous inspection of the entire plot and are small enough to fit within the frequently small extent of topographic uniformity in northeast Iowa forests.

At the top of the survey form (Fig. 1), we request preliminary information regarding the geographic location and ownership of the forest, plot number, surveyor name, date, terrain, slope aspect (if applicable) and other miscellaneous features (evidence of current grazing or logging, tree girdling, etc.) observed during survey (part A, B). Then, we request information regarding the size of the trees (part C). The surveyor locates and measures the dbh (cm) of the largest tree in each of the four principal quadrants of the plot, then records the species and dbh of these four trees in the blanks provided on the form.

This survey methodology assumes that woody vegetation (excluding vines) in northeast Iowa forests commonly occurs in three layers: a *canopy* (all trees with canopy exposed to the sky); a *subcanopy* (all trees greater than 2 m in height and underneath the canopy or in a canopy gap) and a *shrub* layer (all woody vegetation between 0.5 m and 2 m in height). To characterize the structural development of a forest, the surveyor estimates and records the total cover provided by woody species (excluding vines) in the canopy, subcanopy and shrub layers of the plot (parts D, F and H). The cover classes provided on this form are modified slightly from the Braun-Blanquet cover scale commonly used in releves (Mueller-Dombois and Ellenberg 1974).

For each of the above forest layers, we provide space (parts E, F and I) for the surveyor to record the component woody species. For canopy and subcanopy trees, all species are assigned to one of two cover classes: 1) At least 25% Cover and 2) Less than 25% Cover. For the shrub layer, all species are assigned to one of three cover classes: 1) At Least 25% Cover, 2) Between 10% and 24% Cover, and 3) Less than 10% Cover. These cover classes are broader than those typically used in releve (Mueller-Dombois and Ellenberg 1974) to facilitate rapid survey and to clearly establish which species are "dominant" in each forest stratum (for evaluation purposes).

We have added a final category, "Total Cover by Disturbance Indicators" (part J), in which the surveyor estimates the total cover by all shrubs that indicate severe recent disturbance in a forest. A list of all common shrub species that indicate recent grazing and/or logging activity is provided on the survey form (Fig. 1). Although the occurrence of each individual shrub species will already have been recorded in the "Shrub Composition" category (Part I), we feel that this composite estimate of cover by disturbance indicators allows the surveyor to quickly infer recent landuse practices in a forest and therefore provides information supplementary to the other categories.

Evaluation Methodology

Definition of "Natural Quality"

For purposes of evaluation, we define *natural quality* as the condition (maturity, structural diversity, dominance patterns) of a forest relative to that same forest in the absence of recent (50 to 75 yr) major anthropogenic disturbance (timber harvest, pasturing, etc.). We assumed that forests protected in state parks and preserves provide the best examples of high quality forests in northeast Iowa because they are botanically diverse and have been long withheld from cattle grazing and logging. Therefore, we used these areas (henceforth referred to as "protected forests") as standards when calibrating the evaluation method.

Evaluation Criteria

We developed a multi-criteria method for evaluating the natural quality of forests in northeast Iowa (Tables 1, 2). To apply our method, the surveyor must first survey the woody vegetation in 0.10 ha circular plots (described above). Then, the surveyor assigns numerical scores to each of six criteria (Tree Size, Tree Structure, Shrub Structure, Canopy Dominance, Subcanopy Dominance, Shrub Dominance) based on explicit rules (Table 1). The sum of these scores yields a natural quality rating (Q) that ranges in value between 0 and 20, with 20 representing the highest natural quality.

To calibrate the scoring rules for first three criteria (i.e., Tree Size, Tree Structure, Shrub Structure), we used the survey data collected from 72 plots in seven protected forests in northeast Iowa (Tables 3, 4). To calibrate the Dominance component, we relied both upon this survey data from protected forests (not shown) as well as our personal knowledge of other high quality forests in northeast Iowa to generate lists of expected tree and shrub species (Table 2).

Tree Size Allocation of points within the Tree Size category is based on the assumption that high quality forests are characterized by large trees. To score this category, the evaluator must first compute the mean dbh for the four trees measured during survey of woody vegetation in the plot, then use this value to assign points as described in Table 1. A maximum of four points is assigned whenever the mean dbh for a plot is at least 50 cm; no points are assigned when this mean is less than 20 cm.

Structure An assumption of the method is that high quality forests possess canopy, subcanopy and shrub layers. The canopy layer is defined to be composed of all trees with crowns exposed to the sky. The subcanopy layer encompasses all trees greater than 2.0 m in height and beneath the canopy (or in a canopy gap). The shrub layer is composed of all shrubs and small trees between 0.5 and 2.0 m in height.

Points are assigned separately for tree (> 2.0 m) and shrub (0.5-2.0 m) structure. High quality forests are assumed to have well developed canopy and subcanopy layers with at least 50% cover, based on their patterns of occurrence in mature forests in state preserves and parks (Table 4). When these layers are both present (> 50% cover) and easily distinguished by the surveyor, a maximum score is assigned for Tree Structure. When only one of these layers is present, or both are present but difficult to distinguish, one point is assigned for this criterion. The latter condition is frequently observed on young floodplain forests dominated by elm (*Ulmus* spp.) or boxelder (*Acer negundo*) where canopy and subcanopy layers have not had time to differentiate. Finally, a forest in which neither canopy nor subcanopy contribute 50% cover in the plot receives no points for overstory structure.

Shrub cover seldom exceeds 50% total cover in the understory of most northeast Iowa forest preserves (Table 4), no doubt reflecting the closed canopies predominant in these forests. On the other hand, we have observed that the understories in recently grazed or logged forests frequently have shrub cover well in excess of 50%. Our scoring for Shrub Structure reflects these differences (Table 1). Forests in which shrub cover is between 1% and 10% receive the maximum points for this subcategory but no points when understory cover is greater than 50%.

Dominance Topographic position strongly influences the dominance patterns of forests in northeast Iowa forests (Cahayla-Wynne and Glenn-Lewin 1978). Therefore, we have prepared separate lists of canopy and subcanopy trees typical of forests found on ridgetops, slopes and bottomlands in northeast Iowa (Table 2). These lists, an essential aid when scoring the dominance criterion, were generated from inspection of our survey data (not shown) from northeast Iowa forest preserves as well as our own personal knowledge of other high quality forests in northeast Iowa. In our methods, “dominant” canopy and subcanopy species are defined as trees with at least 25% cover as listed on the survey form (Fig. 1).

To illustrate the scoring of Canopy Dominance, consider a forest plot surveyed on a ridge. If white and red oak are recorded as the canopy dominants (i.e., providing at least 25% cover) on the survey form, then a maximum score is awarded for this criterion because both of these species are typical canopy dominants of forests on ridgetops (Table 2). On the other hand, if the canopy dominants in the plot are white oak and black walnut, only one point is scored in this category because dominance by the latter species is not characteristic of high quality forests on ridgetops. In fact, the presence of dominant black walnut on a ridgetop is strong evidence for recent disturbance because this species is shade intolerant. Finally, no points are awarded if black walnut is recorded as the sole canopy dominant in this ridge plot. Scoring for the Subcanopy Dominance criterion follows the same procedure (Table 1).

Occasionally, no dominant species are listed for one of these forest layers. In this situation, the evaluator determines what percent of all the species listed are known to frequent high quality forests in the given topographic position and forest strata (Table 2). If at least 75% of the species are typical residents of the forest type, then maximum points are awarded; if less than 50% are typical, no points are awarded. (Note that some tree species receive credit for being "typical residents" of a particular forest type even though dominance by the species in that same forest would be penalized; i.e., red elm in the canopy of an upland forest). The same process is followed in evaluating subcanopy dominance (Table 1).

No clearcut pattern of species dominance occurs in the shrub layer of protected forests in northeast Iowa. However, thickets of prickly shrubs (characteristic of recently grazed/logged forests) are almost never encountered in protected Iowa forests (Table 5). Therefore, the assignment of points in the Shrub Dominance criterion is based on shrub cover by disturbance indicators recorded in the plot; the scoring rules are straightforward (Table 1).

Originally, we planned to evaluate the Species Richness of canopy, subcanopy and shrub layers as separate criteria in our methodology. However, examination of species richness patterns in survey data obtained from 0.10 ha circular plots in protected forests reveals no clear trend for high species richness for any of these layers (Table 6). Therefore, we omitted these criteria from our evaluation methodology.

Natural Quality Levels.

We define four natural quality levels for use with this methodology: A) Highly Natural, B) Moderately Natural, C) Moderately Altered and D) Highly Altered. Each quality level is defined to reflect the degree of congruence with protected forests (Table 7). The range of possible index values (0-20) is subdivided to correspond with these natural quality levels based on our personal knowledge of the surveyed forests and their corresponding quality ratings.

Summarization of Indices for Forest Evaluation.

There are several possible approaches for summarizing the natural quality indices calculated from multiple plots in a forest; the choice depends on the goal of the project. If the goal is to evaluate the natural quality of the forest as a whole, then the evaluator can simply calculate the mean index value for the site. An alternative method, if one wishes to highlight the best features of a forest, is to order the indices and then compute the mean of the best portions (e.g., the top 90% or 75%) of them). This latter approach may be preferable if the evaluator is concerned that several low scores (i.e., outliers) will mask the true quality of a site.

Field Work and Data Analysis

A total of 75 forests were surveyed in northeast Iowa in 1994, 1995 and 1996. These forests were identified from USGS quadrangle maps of the region. Field work was conducted by twelve technicians who had received two weeks of training in woody plant identification and use of the survey methodology.

We established the minimum number of plots in each forest site to be proportional to total forest area such that one plot was allocated for every 20 ha of forest area, plus two additional plots. The two additional survey plots were allocated to increase the number of plots surveyed in small forest tracts. More plots were allocated in topographically diverse forest sites than specified by this minimum rule. The above guidelines for plot allocation were established to accomodate budgetary and staff constraints of the 3 year songbird versus forest quality study. Prior to survey, all survey plots were marked on a topographic map of each forest to represent all available topographic aspects (i.e., ridgetop, slope, bottomland).

From the pool of 75 forest sites surveyed, 44 were selected for use in the bird study and were evaluated using the above methodology. We calculated summary statistics to describe the distribution of the quality ratings (mean, standard deviation) for each site and then classified each site as Highly Natural, Moderately Natural, Moderately Altered or Highly Altered based on the mean value for each site. We then calculated the minimum sample size, n, needed to estimate the mean within 15% using a confidence interval using the formula (Ashley 1978):

$$n = 4*(cv/e)^2$$

where cv is the coefficient of variation and e is the desired half width of the confidence interval (i.e., 15%).

Finally, we calculated correlation coefficients (r) for all possible combinations of scoring criteria to explore interrelationships among criteria. These were calculated using data from all survey plots (n = 404).

RESULTS

Using the evaluation methodology presented in the Methods, 9 sites (1357.4 ha) were classified as Highly Natural; 23 (3084.2 ha) sites were classified as Moderately Natural, 11 (931.4 ha) were classified as Moderately Altered and 1 (66 ha) was classified as Highly Altered (Table 8).

The theoretical minimum number (N(15%)) of sample plots needed to estimate the mean quality of each site with a confidence interval half width of 15% of $\overline{X}$ are given in Table 8. Our actual allocation of sample plots (N) was sufficient for accurate estimation (15% error margin) of the mean quality of 59% (26 of 44) of our study sites. Of the 18 study sites for which our sampling strategy resulted in estimates with greater error, 14 of them (78%) were smaller than 100 ha in area. This suggests that our sample plot allocation rule for small plots was insufficient as implemented. One alternate strategy would be to allocate a minimum of 6 plots to all forest sites, plus one additional plot for every 15 ha of area. If the number of sample plots had been allocated using this rule (Table 8, N(Alt)), 36 of 44 (82%) study sites would have been sufficiently sampled (i.e., N(Alt) $\geq$ N(15%)) to estimate the mean with a confidence interval half width of 15% of $\overline{X}$.

Strong correlation was found for only one pairing of evaluation criteria (Table 9): Shrub Layer Structure versus Shrub Layer Dominance (r = 0.4465). Three other pairings showed moderate correlation: Canopy Dominance versus Subcanopy Dominance (r =

0.2854), Tree Size versus Tree Structure ($r = 0.2440$) and Subcanopy Dominance versus Shrub Dominance ($r = .2083$). Analysis of the other eleven possible pairings (73%) revealed little or no correlation ($|r| \leq 0.20$).

DISCUSSION

Conceptual Issues in Conservation Evaluation

What is "Natural Quality?"

The concept of "naturalness" has been subject to much discussion in the conservation literature (Moir 1972, Jenkins and Bedford 1973, Margules and Usher 1981, Smith and Theberge 1986). As applied to vegetation communities, most definitions of the term imply freedom from human influence (Margules and Usher 1981). Strict adherence to this definition would preclude conservation evaluation anywhere in the agricultural Midwest because virtually all plant communities in this region are modified to some degree. Therefore, an effective methodology for evaluation of natural areas in the Midwest must be pragmatic and award maximum quality ratings to sites observed to be minimally impacted by humans.

On what basis can "minimum impact by humans" be measured? One common method is to award maximum points when the majority of species are native (Margules and Usher 1981, Smith and Theberge 1986). This philosophy underlies the scoring rules of the Dominance criterion of our methodology because points are deducted whenever non-native species are observed to be dominant in any forest stratum (Table 1).

Another approach for measuring the "naturalness" of an area is to compare the existing vegetation with quantitative descriptions of presettlement vegetation involving "comparison of the percentages of area covered by different vegetation types defined both by species composition and structure" (Smith and Theberge 1986). Although quantitative data exist for the vegetation present between 1832 and 1859 in northeast Iowa (Anderson 1996), they are not of sufficient detail to be applicable for our purposes. Occasionally, researchers attempt to reconstruct pre-settlement vegetation from existing vegetation. This process is problematic for forests in northeast Iowa because different fire regimes are believed to have influenced forest development prior to (i.e., frequent, widespread) and after (i.e., repression) European settlement in the Midwest (Noss 1985).

We used survey data obtained from protected forests long withheld from direct human impacts (cattle grazing, logging) as our standard when calibrating the scoring rules of our evaluation methodology. These protected forests are botanically diverse and may retain some pre-settlement character, but we make no pretension that they provide surrogates for pre-settlement conditions. We agree with Jenkins and Bedford (1973) that " . . The more natural and protected .. an area is, the better will it be suited for supplying baseline data." Thus, we conclude that forests protected in state preserves and state parks in northeast Iowa are the best available standards for natural quality in this region.

Evaluation Criteria Used Elsewhere

Smith and Theberge (1986) reported that Rarity, Diversity, Size and Naturalness were the most frequently used criteria among 22 evaluation systems reviewed. The six criteria used in our system fall within the realm of "Naturalness" because each compares existing vegetation with that known to occur in protected (i.e., "natural") forests. We had originally planned to incorporate Diversity in our methodology and to base the scoring rules on species richness (separately for canopy, subcanopy and shrub layers). However, no clear trend for high species richness is apparent from examination of data (0.10 ha circular plots) surveyed in protected forests (Table 6). Thus, we omitted Diversity from our methodology.

Common sense dictates that the landscape characteristics of a natural area (e.g., Size, Buffer, Isolation, etc.) should be considered in decisions regarding management and future acquisition of natural areas. Larger habitats are generally more diverse than smaller ones; furthermore, many organisms are interior specialists and require a minimum "core area" for survival (e.g., Faaborg et al. 1995). Our evaluation methodology measures "natural quality" on the basis of vegetation characteristics; no attempt is made to evaluate Size, Buffer, or any other such criterion. However, it would not be difficult to add criteria that would allow evaluation of landscape features. For instance, Ogle (1981) developed an evaluation system for New Zealand forests in which seven criteria (including both vegetation and landscape elements) are scored and then summed to yield a single index for priority ranking. Alternatively, one could evaluate vegetation, landscape and other criteria separately and then conduct priority ranking in stages (Margules 1986). In this scenerio, potential sites for protection are initially identified on the basis of a single, highly valued criterion (e.g., Natural Quality); then, narrowing of this pool occurs sequentially on the basis of other criteria (e.g., Landscape Features, Floristic Assessment, etc.).

<u>Independence, Weighting and Aggregation of Criteria Scores</u>

Independence of Criteria It is highly desirable to choose evaluation criteria which provide independent information about the natural quality of a site. It is not difficult, however, to find examples where two or more interrelated criteria are used together for evaluation purposes (e.g., species diversity and site area). Obviously, the use of highly correlated criteria introduces unwanted redundancy into natural area evaluation. In our methodology, only two of the six criteria (Shrub Structure and Shrub Dominance) were highly correlated ($r = 0.4465$, Table 9). Practitioners who choose to adopt our methods for evaluation of hardwood forests elsewhere in the Midwest may wish to omit one or the other of these criteria.

Weighting of Criteria The weighting of evaluation criteria is a common practice (Smith and Theberge 1987). In some applications, criteria are measured over a uniform interval and then multiplied by weights prior to summation. In other methods (including our own), weighting is implicit in that different maximum values are possible for criteria scores (Smith and Theberge 1987). The assignment of weights to criteria is subjective by nature and has been found to vary widely among ecologists and land managers (Margules and Usher 1984). It is imperative, then, that an evaluator explicitly state his/her reasons for assigning different weights to criteria when presenting methods for natural area evaluation.

In our methodology, the most obvious weighting occurs in the scoring of the dominance criteria. The maximum score for both Canopy Dominance and Shrub Dominance is 4, but Subcanopy Dominance has a maximum score of 2. We based this weighting on our perceptions that changes in canopy and shrub dominance patterns are more informative in revealing recent human disturbance than changes in subcanopy dominance.

Aggregation of Criteria Scores In natural area evaluation, the practice of adding criteria scores to yield a single index value is widespread but has been recently criticized by some authors (Margules and Usher 1981, Smith and Theberge 1987). One problem with the summation of criteria scores is philosophical: are the measurement units for each criterion equivalent? In other words, does a unit increase in the score of several different criteria imply equivalent gains in natural quality? Another problem with additive systems is that a site with one outstanding feature may not rank as highly as another site which is average for all criteria (Gotmark et al. 1986). Although the practice of forming evaluation indices through summation of criteria scores may not always be entirely satisfying ecologically and mathematically, it is a straightforward method that is easily understood by non-biologists (city planners, land managers, etc.). Hence, this approach for generating natural quality indices is likely to continue in conservation evaluation.

Establishing Lists of Natural Forest Residents.

We believe that our methodology for natural quality evaluation of hardwood forests in northeast Iowa can be easily modified for use elsewhere in the Midwest. However, *future evaluators will need to develop new lists of typical tree species in the canopy and subcanopy layers of forests in their region.* Our lists were generated after inspection of survey data in protected forests in northeast Iowa and their use should be limited to evaluation of forests there. In fact, we developed different lists of expected tree species for evaluation of central Iowa forests during a similar study (Norris and Farrar, in press).

Comparison Among Evaluation Methodologies Used in the Midwest

The three major evaluation methodologies developed for use in the Midwest (floristic quality assessment, intuitive evaluation, multi-criteria evaluation) have different assumptions and require different levels of expertise and survey intensity. For instance, floristic quality assessment is based on the assumption that natural quality is a function of floristics; i.e., high quality natural areas possess a large number of plant species with conservative habitat preferences (Swink and Wilhelm 1994). Obviously, application of this method is restricted to localities for which complete floristic knowledge is available. Another prerequisite for use of this method is that the evaluator(s) have strong plant identification skills. As for survey intensity, Swink and Wilhelm (1994) suggest that accurate determination of a site's overall floristic quality would require several intensive surveys over one or two growing seasons.

White's "intuitive" approach to evaluation is based on the assumption that the natural quality of an ecological community is a function of disturbance processes and succession (White 1978). Since no formal surveys are called for by this method, intuitive evaluation requires professional-level experience on the part of the surveyor. Although we agree that experienced evaluators can successfully perform intuitive evaluations, we also agree with Swink and Wilhelm (1994) that this approach is subject to inconsistencies, especially when conducted by different personnel. Thus, application of these methods may be susceptible to challenge by developers, lawyers, and others who desire to circumvent environmental protections afforded by virtue of intuitive evaluation methods.

Our multi-criteria methodology implemented for evaluation of northeast Iowa forests (and presented here) is likewise based on assumptions that consider ecological disturbance concepts. For instance, points are deducted when the condition of a forest reflects anthropogenic impacts such as cattle grazing and logging. However, vegetation assemblages maintained by natural disturbance regimes (i.e., floodplain forests) are not penalized in our methodology. Furthermore, our method assumes that the best models of high quality forests in northeast Iowa occur in state parks and preserves in that region. Hence, we calibrated the scoring rules for our evaluation criteria with respect to these protected forests.

By its very nature, evaluation is a subjective process (van der Ploeg and Vlijm 1978, Margules 1986, Smith and Theberge 1987, Swink and Wilhelm 1994, Norris and Farrar 1999). The assumptions of all the above methods reflect the biases of the evaluators. How then does one select a method for use in a particular project? At least three factors will normally influence this decision: the objectives of the research; the amount of time allocated for the research (field work, data analysis, report writing, etc.) and the degree of taxonomic expertise possessed by technicians hired to carry out the work.

In this study, the major research objective was to determine how forest management affects the composition of songbird communities in northeast Iowa. Birds are well known to be influenced by forest structure (MacArthur and MacArthur 1961), hence it was natural for us to incorporate the Tree Size and Structure components in our evaluation methodology. The scoring of our last three criteria (i.e., Canopy Dominance, Subcanopy Dominance, Shrub Dominance) relies solely on the identification of woody plant species. The technicians who worked on this project were trained for two weeks in woody plant identification prior to conducting actual surveys. They did not have strong backgrounds in herbaceous plant identification and thus we were unable to incorporate an evaluation of the herbaceous layer in our methodology.

Recommended Future Research

Proponents of quantitative evaluation techniques almost always defend their methods by asserting that they are "repeatable" in the hands of different users (Swink and Wilhelm

1994, Norris and Farrar 1999). However, very little research is published to support these claims. One test of the repeatability of our own methods would be an analysis of observer differences when pre-established plots are surveyed and evaluated by different observers.

Another possible direction for future research would explore differences in perception of "high", "medium" and "low" quality forests among different observers. The methods presented in this paper are based on assumptions that reflect our biases as professional botanists. It is possible that our concepts of natural quality do not concur with those held by professionals in other, related fields (foresters, arboretum managers, naturalists). An interesting study would be to ask different natural resource professionals to independently visit a number of forest sites that we have evaluated and to assign quality values (1-20) to them based on their intuitive impressions. Then, the quality values obtained from each evaluator could be ranked to allow analysis of differences in rank order among observers. Margules (1984) and Margules and Usher (1984) conducted such a study for evaluation of natural areas in England and found that, while there was some consensus in the ranking of "high" and "low" quality sites, there was great disparity among the quality ratings assigned to sites between these extremes.

Conclusions

Natural areas will continue to come under development pressure in the Midwest and elsewhere, thus necessitating future evaluation and priority ranking of these areas by land managers and conservationists. We feel that these individuals should be aware that different options exist for these tasks, each with its own assumptions, strengths and weaknesses. When large-scale survey and evaluation of natural areas are to be conducted by numerous technicians with limited field experience, uniform procedures for collection and interpretation of survey data are desirable. Individuals charged with overseeing the large scale reconnaissance and priority ranking of natural areas in the Midwest may want to consider the survey and evaluation methodologies described in this paper.

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RAPID ASSESSMENT PLOT (18 M RADIUS)

County: ____________________ USGS Quadrangle: ________________________

Site Letter: ______ Site Name: ____

Tract Landowner: ________________________ Contact Person: ____________________________

Survey Point #: ______ Date: _____________ Observer(s): ______________________________

A) TERRAIN Topography (Choose One): __________

NR (Narrow Ridgetop/Hogback) SS (Steep Slope) NB (Narrow Creek Bottom)
WR (WideTable Ridge) GS (Gentle Slope) WB (Wide Bottomland)

Aspect (Choose One if Sl;ope): ____________ N, NE, E, SE, S, SW, W, NW

B) MISCELLANEOUS FEATURES Indicate any of the following that are evident: _______________

OP (open-grown trees) GR (current livestock grazing) LG (logging in the last 5 years)
GD (girdling of trees) RO (large, massive rocky outcrops) ST (siltation)
other (please describe) ____.

C) TREE SIZE Indicate species and DBH of the largest tree in each quadrant of the plot (within 18 m).

Quadrant	Species	DBH (cm)
NE	____________________	________
SE	____________________	________
SW	____________________	________
NW	____________________	________

Figure 1. Form developed for rapid survey of woody vegetation of 0.10 ha circular plots in hardwood forests of northeast Iowa.

D) TOTAL CANOPY[1] COVER Indicate the percent of the plot that is covered by canopy trees:________

a) 0-24% b) 25-49% c) 50-74% d) 75-100%

E) CANOPY[1] COMPOSITION Indicate species with:

At least 25% Total Cover:

________________ ________________ ________________ ________________

Less than 25% Total Cover:

________________ ________________ ________________ ________________

________________ ________________ ________________ ________________

________________ ________________ ________________ ________________

F) TOTAL SUBCANOPY[2] COVER Indicate the percent of the plot that is shaded by small trees, saplings, shrubs and twining vines > 2 M tall but beneath the canopy. __________

a) 0-24% b) 25-49% c) 50-74% d) 75-100%

G) SUBCANOPY[2] COMPOSITION Indicate species with:

At least 25% Total Cover

________________ ________________ ________________ ________________

Less than 25% Total Cover

________________ ________________ ________________ ________________

________________ ________________ ________________ ________________

Figure 1. (continued)

H) TOTAL SHRUB[3] COVER Indicate the total percent of the plot that is shaded by small trees, saplings, and shrubs < 2 M tall. __________

a) < 1% b) 1-10% c) 11-25% d) 26-50% e) 51-75% f) 76-100%

I) SHRUB[3] COMPOSITION Indicate species with:

At least 25% Total Cover

________ ________ ________ ________

Between 10% and 25% Total Cover

________ ________ ________ ________

________ ________ ________ ________

Less than 10% Total Cover

________ ________ ________ ________

________ ________ ________ ________

________ ________ ________ ________

J) TOTAL COVER BY DISTURBANCE INDICATORS The following may indicate recent human disturbance:

cultivated honeysuckle	hawthorn	honey locust	european buckthorn
multiflora rose	Missouri gooseberry	prickly ash	barberry
black raspberry	blackberry		

Indicate the total percent cover by the above shrubs (all species combined) in the plot.__________

a) 0-1% b) 2-9% c) 10-24% d) 25-49% e) 50-74% f) 75-100%

---

[1] A "canopy" plant has its crown exposed to the sky not due to a canopy gap
[2] A "subcanopy" species is any woody plant at least 2 m high and beneath the canopy.
[3] A "shrub" is any woody plant less than 2 meters high

Figure 1. (continued)

Table 1. Method used for the natural quality evaluation of forests in northeast Iowa. Points are assigned for each of three major categories: Tree Size (T), Structure (S) and Dominance (D). These are summed to yield a natural quality rating (Q) which ranges from 0 to 20 points. High values of Q indicate high congruence with mature forest communities developed in the absence of recent (last 75 yrs) human induced disturbance; low values indicate high levels of recent human induced disturbance.

I) <u>TREE SIZE</u>

4	Mean dbh (of the largest tree in each quadrant) at least 50 cm
3	Mean dbh between 40 and 49 cm
2	Mean dbh between 30 and 39 cm
1	Mean dbh between 20 and 29 cm
0	Mean dbh less than 20 cm

T = _____

II) <u>STRUCTURE</u>

A) Trees (woody vegetation > 2 m in height, excluding vines)

3	Two layers (canopy and subcanopy) present with at least 50% cover and clearly distinguished
1	Only one layer (canopy or subcanopy) present with at least 50% cover OR both layers present but not clearly distinguished
0	Neither canopy or subcanopy with at least 50% cover

_____

Table 1 (continued).

B) Shrubs (woody vegetation between 0.5 m and 2 m in height)

3	Between 1% and 10% cover
2	Between 11% and 50% cover
1	Less than 1% cover
0	More than 50% cover

_____

S = _____ (sum of scores))

III) <u>DOMINANCE</u>

A) Canopy trees with crowns exposed to open sky

4	All species with at least 25% cover are naturally dominant in the given habitat [1]
2	Some (but not all) of the species with at least 25% cover are naturally dominant in the given habitat
0	None of the species contributing at least 25% canopy cover are naturally dominant in the given habitat

_____

Table 1 (continued).

B) Subcanopy (woody vegetation > 2 m in height and beneath the canopy or in a canopy gap)

2	All species with at least 25% cover are naturally dominant in the given habitat [1]
1	Some (but not all) of the species with at least 25% cover are naturally dominant in the given habitat
0	None of the species contributing at least 25% canopy cover are naturally dominant in the given habitat

______

C) Shrub/Seedlings (woody vegetation between 0.5 m and 2 m in height)

4	Cover by disturbance indicators less than 1% [2]
3	Cover by disturbance indicators between 1% and 10%
1	Cover by disturbance indicators between 11% and 25%
0	Cover by disturbance indicators more than 25%

______

D = ______ (sum of scores)

Q = ______ (T + S + D)

---

[1] See Table 2 for lists of naturally dominant species for canopy and subcanopy on ridgetops, slopes and bottomland habitats in northeast Iowa. If no species are recorded as dominant (at least 25% cover) on the survey form for the given forest layer and habitat, score 3 points if at least 75% of the listed species are natural residents; 2 points if between 50% and 74% of the species are natural residents; and 0 points if less than 50% of the species are natural residents.

[2] When scoring the shrub/seedling dominance category, consider the following species to be disturbance indicators: *Berberis* sp., non-native *Lonicera* species, *Ribes missouriense*, *Rhamnus cathartica*, *Rosa multiflora*, *Rubus* sp., and *Zanthoxylum americanum*.

Table 2. Lists of canopy and subcanopy trees (> 2m in height) found frequently to occasionally as natural residents in northeast Iowa forests. Species naturally resident but not normally dominant in mature forests are indicated with an asterisk (*).

A) RIDGETOP

Canopy

Acer saccharum Marsh.
Carya ovata L.
Fraxinus americana L.
**Juniperus virginiana* L.
Pinus strobus L.
**Populus gradidentata* Michx.
**Populus tremuloides* Michx.
**Prunus serotina* Erhr.
Quercus alba L.
Quercus ellipsoidalis E.J. Hill
Quercus macrocarpa Michx.
Quercus muhlenbergii Engelm.
Quercus rubra L.
Quercus velutina Lam.
**Tilia americana* L.
**Ulmus rubra* Muhl.

Subcanopy

Acer saccharum Marsh.
Amelanchier Medicus sp.
**Betula papyrifera* Marsh.
**Carya cordiformis* (Wang) K. Koch
Carya ovata L.
**Cornus drummondii* C.A. Meyer
**Cornus foemina* P. Miller ssp. *racemosa* (Lam.) J.S. Wilson
**Corylus americana* L.
Fraxinus sp.
**Juniperus virginiana* L.
Pinus strobus L.
Ostrya virginiana (P. Miller) K. Koch
**Populus gradidentata* Michx.
**Populus tremuloides* Michx.
**Prunus serotina* Erhr.
**Prunus virginiana* L.
Quercus alba L.
Quercus ellipsoidalis
Quercus macrocarpa
Quercus muhlenbergii
Quercus rubra L.
Quercus velutina Lam.
Tilia americana L.
**Ulmus* L. sp.
**Viburnum lentago* L.
**Zanthoxylum americanum* P. Miller

B) SLOPE

Canopy

Acer saccharum Marsh
Betula alleghenensis Britton
**Betula papyrifera* Marsh.
Carya cordiformis (Wang) K. Koch
Carya ovata L.
Fraxinus americana L.
Fraxinus nigra Marsh.
**Juniperus virginiana* L.
Pinus strobus L.
**Populus gradidentata* Michx.
**Populus tremuloides* Michx.
**Prunus serotina* Erhr.
Quercus alba L.
Quercus ellipsoidalis
Quercus macrocarpa
Quercus muhlenbergii
Quercus rubra L.
Quercus velutina Lam.
Tilia americana L.
**Ulmus rubra* Muhl.

Subcanopy

Acer saccharum Marsh.
Amelanchier Medicus sp.
Betula alleghenensis
**Betula papyrifera* Britton
Carpinus carolinianus Walter
Carya cordiformis (Wang) K. Koch
Carya ovata L.
Cornus alternifolia L. f.
**Cornus drummondii* C.A. Meyer
**Cornus foemina* P. Miller ssp. *racemosa* (Lam.) J.S. Wilson
Cornus rugosa Lam.
**Corylus americana* L.
Fraxinus L. sp.
Hamamelis virginiana L.
**Juniperus virginiana* L.
Ostrya virginiana (P. Miller) K. Koch
Pinus strobus L.
**Populus gradidentata* Michx.
**Populus tremuloides* Michx.
**Prunus serotina* Erhr.
**Prunus virginiana* L.
Quercus alba L.
Quercus ellipsoidalis E.J. Hill
Quercus macrocarpa Michx.
Quercus muhlenbergii Engelm.
Quercus rubra L.
Quercus velutina Lam.
Staphylea trifolia L.
Tilia americana L.
**Ulmus* L. sp.
**Viburnum rafinesquianum* Schultes
**Viburnum lentago* L.
**Zanthoxylum americanum* P. Miller

C) BOTTOMLAND

Canopy

Acer negundo L.
Acer saccharinum L.
Acer saccharum Marsh
Carya cordiformis (Wang) K. Koch
Carya ovata L.
Celtis occidentalis L.
Fraxinus nigra Marsh.
Fraxinus pensylvanica Marsh.
Gymnocladus dioica L.
Juglans cinerea L.
Juglans nigra L.
Platanus occidentalis L.
Populus deltoides Bartram ex Marsh.

Table 2 (cont.)

Quercus macrocarpa L.
Quercus muhlenbergii Engelm.
Quercus rubra L.
Salix amygdaloides Andersson
Salix nigra Marsh.
Tilia americana L.
Ulmus americana L.
Ulmus rubra Muhl.
Ulmus thomasii Sarg.

<u>Subcanopy</u>

Acer negundo L.
Acer saccharinum L.
Acer saccharum Marsh.
Amelanchier Medicus sp.
Carpinus carolinianus Walter
Carya cordiformis (Wang) K. Koch
Carya ovata L.
Celtis occidentalis L.
Cornus alternifolia L. f.
**Cornus drummondii* C.A. Meyer
**Cornus foemina* P. Miller ssp. *racemosa* (Lam.) J.S. Wilson
Cornus rugosa Lam.
Fraxinus sp.
**Gymnocladus dioica* L.
Hamamelis virginiana L.
**Juglans cinerea* L.
**Juglans nigra* L.
Ostrya virginiana (P. Miller) K. Koch
**Platanus occidentalis* L.
**Populus deltoides* Bartram ex Marsh.
**Prunus serotina* Erhr.
**Prunus virginiana* L.
Quercus macrocarpa L.
Quercus muhlenbergii Engelm.
Quercus rubra L.
**Salix* L. sp.
Staphylea trifolia L.
Tilia americana L.
Ulmus L. sp.
**Viburnum lentago* L.
**Viburnum rafinesquianum* Schultes
**Zanthoxylum americanum* P.

Table 3. Tree girth of protected forests (state preserves, state parks) in northeast Iowa. Numbers represent the mean dbh (diameter at breast height) of the largest trees (one per quadrant) in a 0.10 ha circular survey plot. S/W Slope = south and west facing slopes; N/E Slope = north and west facing slopes.

			frequency		
Dbh Class (cm)	Ridgetop	S/W Slope	N/E Slope	Bottomland	Total
20 - 29	0	1	0	0	1
30 - 39	0	1	7	3	11
40 - 49	8	10	10	4	32
50 - 59	4	4	7	0	15
60 - 69	2	1	2	0	5
total	14	17	26	7	64

Table 4. Percent cover provided by woody plants in a) canopy, b) subcanopy and c) shrub layers of protected forests (state preserves, state parks) in northeast Iowa. Values were obtained from survey of 0.10 ha circular plots. S/W Slope = south and west facing slopes; N/E Slope = north and west facing slopes.

A) Canopy

			frequency		
Cover Class (%)	Ridgetop	S/W Slope	N/E Slope	Bottomland	Total
0 - 25	0	0	0	1	1
26 - 50	0	0	0	0	0
51 - 75	3	4	8	7	22
76 - 100	11	13	18	7	49
total	14	17	26	15	72

B) Subcanopy

			frequency		
Cover Class (%)	Ridgetop	S/W Slope	N/E Slope	Bottomland	Total
0 - 25	0	0	1	0	1
26 - 50	0	0	1	3	4
51 - 75	6	5	5	6	22
76 - 100	8	12	18	6	44
Total	14	17	25	15	71

C) Shrub

			frequency		
Cover Class (%)	Ridgetop	S/W Slope	N/E Slope	Bottomland	Total
< 1	1	0	1	3	5
1 - 10	7	8	8	9	32
11 - 25	1	5	8	2	16
26 - 50	4	2	8	1	15
51 - 75	0	1	0	0	1
76 - 100	1	1	0	0	2
Total	14	17	25	15	71

Table 5. Percent cover by disturbance indicators in the shrub layer of protected forests (state preserves, state parks) in northeast Iowa. Values were obtained from survey of 0.10 ha circular plots. S/W Slope = south and west facing slopes; N/E Slope = north and west facing slopes.

			frequency		
Cover Class (%)	Ridgetop	S/W Slope	N/E Slope	Bottomland	Total
< 1	10	10	20	7	47
1 - 10	3	4	5	6	18
11 - 25	0	2	1	2	5
26 - 50	0	0	0	0	0
51 - 75	1	0	0	0	1
76 - 100	0	0	0	0	0
	—	—	—	—	—
Total	14	16	26	15	71

Table 6. Species richness of woody plants (non-vines) in canopy, subcanopy and shrub layers of protected forests (state preserves, state parks) in northeast Iowa. Values were obtained from survey of 0.10 ha circular plots. S/W Slope = south and west facing slopes; N/E Slope = north and east facing slopes.

A) Canopy

	frequency				
Species Richness	Ridgetop	S/W Slope	N/E Slope	Bottomland	Total
1	0	0	0	1	1
2	1	2	1	3	7
3	2	3	6	2	13
4	6	2	9	2	19
5	1	5	5	4	15
6	2	1	3	2	8
7	1	4	2	0	7
8	0	0	0	1	1
9	1	0	0	0	1
total	14	17	26	15	72

B) Subcanopy

	frequency				
Species Richness	Ridgetop	S/W Slope	N/E Slope	Bottomland	Total
1	0	0	0	1	1
2	0	0	0	0	0
3	2	1	2	0	5
4	4	1	4	3	12
5	1	4	0	1	6
6	1	1	3	1	6
7	1	1	5	0	7
8	0	3	3	5	11
9	1	2	3	1	7
10	1	0	2	0	3
11	2	1	2	1	6
12	0	1	2	1	4
13	1	2	0	0	3
14	0	0	0	0	0
15	0	0	0	1	1
total	14	17	26	15	72

Table 6. (continued)

C) Shrub

Species Richness	Ridgetop	S/W Slope	frequency N/E Slope	Bottomland	Total
1	0	0	0	1	1
2	0	1	0	0	1
3	0	0	0	1	1
4	1	0	0	6	7
5	2	0	0	1	3
6	2	0	2	1	5
7	1	0	2	0	3
8	2	0	1	1	4
9	0	0	1	3	4
10	2	0	1	0	3
11	0	0	3	0	3
12	1	3	1	0	5
13	0	1	1	0	2
14	0	1	6	1	8
15	1	4	0	0	5
16	0	1	2	0	3
17	2	0	1	0	3
18	0	0	2	0	2
19	0	0	1	0	1
20	0	1	0	0	1
21	0	2	0	0	2
22	0	1	2	0	3
23	0	2	0	0	2
total	14	17	26	15	72

Table 7. Descriptions of natural quality levels for forests in northeast Iowa. The term "protected forests" refers to forests that have been withheld from grazing and logging for at least 50 years via state preserve/state park designation.

A. *Highly Natural.* Undisturbed forests whose structural attributes and species dominance patterns are characteristic of protected forests. Large trees (dbh greater than 40 cm) are frequent; canopy and subcanopy layers are well developed and clearly delineated; the shrub layer is diffuse (between 1-10% cover); and dominant species in canopy, subcanopy and shrub layers are natural residents of the area (Q = 17, 18, 19, 20).

Example: Forests which have not been grazed or logged for at least 50-75 years.

B. *Moderately Natural.* Lightly disturbed forests that closely resemble protected forests with respect to structural attributes and species dominance patterns. Large trees (dbh greater than 40 cm) are frequent; canopy and subcanopy layers are well developed and clearly delineated in many places; the shrub layer is well developed (1-25 % cover) but not dense; and dominant species in canopy, subcanopy and shrub layers are usually natural residents (Q = 14, 15, 16).

Example: Forests which have experienced light grazing or logging in the past 50 years.

C. *Moderately Altered.* Moderately disturbed forests that have some resemblance to protected forests but whose structural attributes and species dominance patterns differ to a considerable extent. Medium-sized trees (dbh between 30 and 40 cm) are predominant; canopy and subcanopy layers are poorly differentiated; the shrub layer is often dense (between 25 and 50% cover); and dominant species in one or more forest layers are untypical (Q = 10, 11, 12, 13).

Example: Forests which have experienced moderate grazing and/or logging in the past 50 years.

D. *Highly Altered.* Highly disturbed forests that have little resemblance to protected forests with respect to structural attributes and species dominance patterns. Small trees (dbh between 10 and 30 cm) are predominant; canopy and subcanopy layers are poorly developed and not readily delineated; the shrub layer is dense (greater than 25% cover) and often impenetrable; and dominant species in at least two forests layers are untypical (Q = 0, 1, 2, . . , 9).

Example: Forests which have been heavily grazed and/or clearcut in the past 50 years.

Table 8. Summary statistics for evaluation of hardwood forests in northeast Iowa (1994-1996). N = actual number of plots surveyed; SD = standard deviation; X = mean quality value, QL = quality level (NH = Highly Natural; NM = Moderately Natural; AM = Moderately Altered; AH = Highly Altered); N(15%) = theoretical number of survey plots needed to estimate the true mean within 15% using a confidence interval; N(Alt) = number of plots allocated under proposed alternative rule (6 + 1 plot per 15 ha). An asterisk (*) denotes an Iowa state park or preserve.

Site Name	Area(ha)	N	X	SD	QL	N(15%)	N(Alt)
Camp Tahigwa	100.4	7	15.7	3.5	NM	9	13
Iverson Bottom	121.4	8	15.4	2.3	NM	4	14
Thompson	66	6	8.3	3	AH	23	10
Buckmaster	124.6	11	14.4	4.3	NM	16	14
Wilke	357.7	16	14.7	3	NM	7	30
Fish Farm Mounds	161.5	9	15.2	3.9	NM	12	17
Leland Weymiller	272.8	13	10.2	3	AM	15	24
Wiegrefe	66.8	7	11.3	2.9	AM	12	10
Grove	93.5	7	12.6	1.6	AM	3	12
Clear Creek	79.3	13	13.5	3.3	NM	11	11
Silver Creek	64.3	5	14.8	2.4	NM	5	10
Louis Weymiller	56.3	5	13	2.4	AM	6	10
Deserted Valley	187	12	15.4	2.4	NM	4	18
Garnavillo East	243.2	13	15.1	2.1	NM	3	22
Cherne	46.1	5	14.6	3.2	NM	9	9
Davis/Moser	46.1	5	15.8	3.7	NM	10	9
Willy/Finegan	103.6	8	14.9	2.3	NM	4	13
*Bixby	23.5	6	18.3	1.6	NH	1	8
*Mossy Glen	33.2	6	17	2.1	NH	3	8
Thurn/Burgin/Jewel	56.3	7	16.9	1.6	NH	2	10
Costigan	89.9	6	10.7	3.9	AM	24	12
Ernst	32.8	5	15.4	1.8	NM	2	8
Thurn	45.3	5	13.4	4.1	AM	17	9
Koether	187.4	15	14.1	3	NM	8	18
*Pike's Peak	200.3	15	16.5	2.9	NH	5	19
Joy Springs	26.7	9	15.7	2.6	NM	5	8
Anderegg Hollow	47.8	5	16.2	3.1	NM	7	9
Blockhus-Corbin	91.1	6	12.8	2.7	AM	8	12
Volga White Pine	46.1	5	14	6	NM	33	9
*Backbone	519.2	24	17.3	2.5	NH	4	41
*White Pine Hollow	328.6	18	17.6	2.4	NH	3	28
*Brush Creek Canyon	87.8	14	17.1	1.6	NH	2	12
Echo Valley	32.8	6	13.3	2.6	AM	7	8
Bruening/Peterson/Strom.	82.6	9	17.2	1.5	NH	1	12
Haga	46.5	5	11.6	2.1	AM	6	9
*Malanaphy Springs	25.9	4	17.3	1.3	NH	1	8
Canoe Creek	59.1	9	11.7	3.8	AM	19	10
Putnam/Hove	48.6	7	14.7	2.6	NM	6	9

Table 8. (continued)

Site Name	Area(ha)	N	X	SD	QL	N(15%)	N(Alt)
Decorah Airport	77.3	8	13.4	2.3	AM	5	11
Bloody Run Creek	212.9	10	13.9	2.3	NM	5	20
Pleasant Valley	51.4	6	15.2	1.5	NM	2	9
Paint Creek	349.7	11	14.7	3.6	NM	11	29
Waukon Junction	82.2	6	15.3	2.8	NM	6	11
Ram Hollow-Hoffman	363.4	24	15.3	3.6	NM	10	30

Table 9. Matrix of Pearson correlation coefficients for six criteria used in evaluation of hardwood forests in northeast Iowa (n = 403 survey plots). TR = Tree Size; STR1 = Tree Structure; STR2 = Shrub Structure; DOM1 = Canopy Dominance; DOM2 = Subcanopy Dominance; DOM3 = Shrub Dominance. Number in parentheses = p > | r | under assumption rho = 0.

	TR	STR1	STR2	DOM1	DOM2	DOM3
TR	1.0000 (0.0)					
STR1	0.2440 (0.0001)	1.0000 (0.0)				
STR2	0.0148 (0.77)	-0.0483 (0.33)	1.0000 (0.0)			
DOM1	0.1698 (0.0006)	-0.0032 (0.95)	0.0305 (0.54)	1.0000 (0.0)		
DOM2	0.1615 (0.0011)	0.1073 (0.031)	0.1515 (0.0023)	0.2854 (0.0001)	1.0000 (0.0)	
DOM3	0.1753 (0.0004)	0.1092 (0.028)	0.4465 (0.0001)	0.1093 (0.028)	0.2083 (0.0001)	1.0000 (0.0)

CHAPTER 5. IS BIRD COMMUNITY COMPOSITION RELATED TO THE "NATURAL QUALITY" OF VEGETATION IN NORTHEAST IOWA FORESTS?

A paper to be submitted to Natural Areas Journal

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Abstract

Most previous studies of bird-habitat relationships in Midwestern forests have excluded recently disturbed habitats from consideration. Here, we ask whether the composition of a forest avifauna is influenced by the "natural quality' of forest vegetation, where "natural quality" is defined as the degree of similarity to mature forests (with respect to tree size, structural attributes and patterns of plant species dominance). We measured the natural quality of 44 forests in northeast Iowa (including mature and recently disturbed forests) using an additive, multi-criteria index ($\overline{Q}$) ranging in value from 0 (low quality) to 20 (high quality). We censused forest birds at these study sites using point counts in 1995 and 1996. Then, we used regression analyses to test for relationships between the abundance and species richness of birds (subsetted by migratory, nest substrate and conservation categories) and ($\overline{Q}$). Although forest quality ($\overline{Q}$) did not strongly influence the abundance of any bird group, the species richnesses (mean number of bird species detected per census point at each site) of short-distance migrants and ground nesting bird species were both higher in low quality forests, and the species richness of high management concern bird species peaked in high quality forests. These results suggest that high quality forest vegetation is important habitat for uncommon and rare bird species in northeast Iowa.

Introduction

Several recent studies (Ambuel and Temple 1983, Blake and Karr 1987) have demonstrated that bird community structure in Midwestern forests is related to both vegetation and landscape characteristics. Significantly, recently disturbed (logged, pastured) forests were excluded from these studies. We argue that these forests are relevant in studies of avian habitat relationships because many resident bird species, especially neotropical migrants, are habitat specialists (Sherry and Holmes 1995) with narrow habitat preferences (successional forests, mature forests, etc.). Furthermore, successional habitats, whether naturally occurring or caused by human activity, often comprise the majority of forest cover in midwestern landscapes (such as northeast Iowa) and thus are part of the universe from which breeding birds select habitat in the spring.

Some attention has been paid to the effects of specific silvicultural practices (e.g., clear cutting, selective cutting) on bird community structure in eastern deciduous and mixed-deciduous forests (Conner and Adkisson 1975, Webb et al. 1977, Whitcomb et al. 1977, Crawford et al. 1981, Horn 1984, Thompson and Fritzel 1990, Thompson et al. 1992, Thompson et al. 1995, 1996); however, we know of almost no published research documenting the effects of pasturing on bird communities in eastern deciduous forests. Logging and pasturing usually modify forest structural characteristics and alter patterns of plant species dominance in one or more forest strata (Webb et al. 1977, Thompson et al. 1995, Chapter 4). Habitat structural characteristics and plant species composition are well known to influence habitat selection (MacArthur and MacArthur 1961, Cody 1981) and foraging behavior (Franzreb, K.E. 1978, Hunter 1980, Wiens and Rotenberry 1981, Holmes and Robinson, 1981, Robinson and Holmes, 1984) of birds; thus, there is little doubt that forest management affects patterns of bird community composition in the Midwest.

In this investigation, we address the effect of forest management on bird communities from a different perspective. Rather than focusing on the effects of specific forest management practices on bird community patterns, we ask whether bird community attributes (abundance, species richness) vary predictably along a gradient of "natural quality" in forest vegetation. Specifically, we developed a quantitative method to measure the degree to which a given forest resembles that same forest (maturity, structural diversity, tree species dominance patterns) in the absence of recent (50 to 75 yr) major anthropogenic disturbance (timber harvest, pasturing, etc.). Our evaluation method (Chapter 4) is an additive, multi-criteria system (Smith and Theberge 1986, 1987) which relies upon the scoring of six evaluation criteria from vegetation survey data, collected in 0.10 ha circular plots, which are summed to yield a natural quality rating (Q) for each survey plot ranging in value from 0 to 20. The mean of these Q values yields an overall natural quality rating ($\overline{Q}$) for each forest site. This enabled us to answer our specific research questions: Are the abundance and species richness of forest birds (subsetted into management assemblages) predictable given the natural quality ($\overline{Q}$) and total area of a forest?

The use of indices to evaluate bird habitat is not unprecedented (Gotmark *et al.*, 1989; Anselin *et al.*, 1989). There are several reasons why we used this approach to evaluate habitat use by birds in northeast Iowa forests. First, the majority of forests in this region are privately owned and have been subject to a wide number of human impacts making it difficult, if not impossible to categorize a given forest as "clear cut", "selectively cut", "pastured", etc. Secondly, protected forests (i.e., those withheld from timber harvest and pasturing for many years) in northeast Iowa are scarce and it is a natural question for wildlife managers and foresters to ask to what extent they are utilized by breeding birds relative to less pristine forests.

Study Area

Field work for this study took place in Allamakee, Clayton, Delaware, Dubuque, Fayette and Winneshiek counties in northeast Iowa. This corner of Iowa was predominantly forested (59% forest cover) in the middle of the last century (Anderson 1996). However, logging and conversion of forested lands to agricultural purposes have reduced this historic forest cover to a patchwork of forest remnants (current forest cover = 19%). Forests in northeast Iowa belong to the Central Hardwoods (Braun 1964) and have been described by Cahayla-Wynne and Glenn-Lewin (1978). The typical canopy dominants of forests on ridgetops and sloping terrain in this region are oak (*Quercus alba* L., *Q. ellipsoidalis* E.J. Hill, *Q. macrocarpa* Michx. and *Q. rubra* L.), maple (*A. saccharum* Marsh.) and American basswood (*Tilia americana* L.). In floodplain forests, black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*) and elm (*Ulmus americana*, *U. rubra*) are the usual canopy dominants.

A small number of northeast Iowa forests (state preserves, state parks, forest reserves) have been protected for many years and have closed canopies, well differentiated canopy and subcanopy layers, diffuse shrub layers and high native plant diversity (Chapter 4). However, the majority of forests in northeast Iowa have been logged and/or grazed within the past two decades. These are characterized by reduced overstory stratification and shrubby understories dominated by prickly shrub species uncharacteristic of mature forests, including gooseberry (*Ribes missouriense* Nutt. ex T. & G.), prickly ash (*Zanthoxylum americanum* P. Miller), blackberry (*Rubus allegheniensis* Porter ex Bailey) and black raspberry (*Rubus occidentalis* L).

Methods

Forest Site Selection

We selected 44 forest sites ranging in area from 32 to 486 ha in northeast Iowa for inclusion in this study. Among these were 17 public lands encompassing several state parks and forest preserves and many wildlife management areas. Among the 27 privately owned sites were forests that had recently been logged and/or grazed as well as others set aside in forest reserve programs. Study sites were not selected from the Mississippi River floodplain because the avifauna of this ecosystem has already been extensively studied (Knutson et al. 1996; Knutson and Klaas1997).

Few forests in northeast Iowa are "patches" in the strict sense (i.e., isolated on all sides from other timber) but rather are connected to other forests by at least a narrow corridor of trees. Thus, our study sites were not isolated "patches" in the sense of Hanski and Simberloff (1997). However, the majority of our study sites were surrounded by cropfields or open pasture along the majority of their borders (80% or more).

We used a stratified random sampling scheme to allocate bird census points to each study site in proportion to area. We marked the center of each bird census point with two parallel bands of white paint and pink flagging on a tree, and placed them at least 50 m from the forest edge so that the entire point (50 m radius) would be within the forest. Census points were situated at least 250 m apart to minimize the possibility of double counting individual birds during a census (Ralph et al. 1993). Our smallest site (32 ha) had two census points and the largest site (486 ha) had twelve such points. Bird census points were thus located in a variety of topographic positions, including upland habitats (ridgetops, slopes, ravines), lowland floodplains and narrow wooded creek bottoms.

Bird Census Protocol

We conducted bird censuses between May 30 and July 15 in both 1995 and 1996. All field technicians working on this project received two weeks of training in bird song recognition immediately prior to conducting these censuses. We followed the protocol established by Ralph et al. (1993) for censusing birds, which always took place on calm, rainless mornings from sunrise to 10:00 AM. All 189 bird census points were censused three times each season at approximately two week intervals, with replicate censuses at each point conducted by different observers to minimize observer bias. Each point count was 10 minutes in duration. We recorded all birds detected during the census as occurring either inside or outside a 50 radius circle centered on the marked tree.

Vegetation Survey Protocol

We used standard releve methods (Mueller-Dombois and Ellenberg 1974) to survey the woody vegetation at each study site. We established numerous 0.10 circular plots in each forest site (independent of the bird points). These vegetation survey plots were allocated in proportion to forest area such that one 0.10 ha plot was established for every 20 ha of forest area, plus two additional plots (to increase the number of plots in small forests). Prior to survey, we marked all survey plots on a topographic map of each forest to represent all available topographic aspects (e.g., ridge, slope, bottomland).

Our survey methodology assumes that woody vegetation (excluding vines) in northeast Iowa commonly occurs in three layers: a canopy (all trees with canopy exposed to the sky); a subcanopy (all trees greater than 2 m in height and underneath the canopy or in a canopy gap) and a shrub layer (all woody vegetation between 0.5 m and 2 m in height). At each survey plot, we recorded the total cover provided by woody species (excluding vines) in each of these layers. Then, we recorded the component woody species occurring in these three layers within broad cover classes. We also estimated and recorded the total cover by shrubs that indicate severe recent disturbance in a forest (e.g., *Ribes missouriense*, *Zanthoxylum americanum*). Finally, we recorded the diameter at breast height (dbh) of the four largest trees within each survey plot: one tree in each of the four cardinal directions. A more detailed description of this survey methodology appears in Chapter 4.

Evaluation of Natural Quality

We developed a method for evaluating the "natural quality" (i.e., degree of resemblance to protected forests in northeast Iowa) of forest vegetation on a scale of 0 to 20. Our method, which is thoroughly described in Chapter 4, relies upon the summation of scores obtained from six evaluation criteria (Tree Size, Tree Structure, Shrub Structure, Canopy Dominance, Subcanopy Dominance, Shrub Dominance) at each survey plot. The rules for assignment of points are explicit and are calibrated with respect to survey data that we obtained in northeast Iowa forest preserves and state parks. A brief description of these six evaluation criteria appears below.

The "Tree Size" criterion (4 pts) is based on tree girth; forests with large trees receive higher scores than those with small trees. The "Tree Structure" (3 pts) criterion is based on degree of development and differentiation of canopy and subcanopy layers in a forest; maximum points are awarded when canopy and subcanopy layers are both present and clearly delineated. In contrast, maximum points are awarded for the "Shrub Structure" (3 pts) criterion when the shrub layer is diffuse (1% to 10% total cover) because this is the condition observed in protected forests. As for the "Canopy Dominance" (4 pts), "Subcanopy Dominance" (2 pts) and "Shrub Dominance" (4 pts) criteria, maximum points are awarded when the dominant tree and shrub species, respectively, are those known to be dominant in the appropriate forest layer in northeast Iowa state preserves.

The scores from all six evaluation criteria are summed to yield a natural quality index (Q) for each 0.10 ha survey plot that ranges in value from 0 (lowest quality) to 20 (highest quality). We obtained a measure of the overall natural quality of each forest study site ($\overline{Q}$) by computing the mean Q value from all survey plots and bird census points therein.

Characterization of Forest Area

The boundaries of our forest sites almost always corresponded to private ownership boundaries. In many cases, these boundaries corresponded to transitions between forest and non-forest habitat; in some cases, they did not. For this reason, we measured the total forest area within a 1-km extension of forest site boundaries (rather than inside the political boundaries of the site) for use in later regression analyses. To do this, we first created an arc coverage (GIS) of site boundaries from 7.5 series USGS quadrangles. From this site coverage, we created a 1-km buffer coverage which we subsequently used to clip a land-use raster coverage classified from recent (1992) 30-m resolution Thematic Mapper (TM) satellite imagery. Finally, we calculated the amount of total forest area within 1 km of site boundaries (A) using FRAGSTATS software (McGarigal and Marks, 1994).

Analysis of Forest Quality Relationships with Avian Abundance and Species Richness

We conducted multiple regression analyses to determine whether forest bird abundance and species richness in northeast Iowa are related to forest area (A) and overall site quality ($\overline{Q}$). Although our primary goal was to determine how forest quality influences the bird community, we included site area (A) as an independent variable because it was found to influence abundance and species richness of forest birds elsewhere in the Midwest (Ambuel and Temple, 1981; Blake and Karr, 1987; Hayden et al., 1987). Prior to conducting regression analyses, we calculated the correlation coefficient (r) between site area (A) and site quality ($\overline{Q}$) to test for collinearity.

We conducted separate analyses for total birds as well as for "management assemblages" determined by migratory class (neotropical migrants, permanent resident, short-distance migrant), nest substrate (cavity, ground, shrub, tree), level of management concern and area sensitivity. The assignment of birds to the migratory and nest substrate assemblages is based on assignments given in Best et al. (1996). Birds grouped together as "high management concern" species are neotropical migrants with high values (≥ 3.0) for a conservation priority index (PIF = Partners' in Flight Index) developed by the U.S. Fish and Wildlife Service (Thompson et al. 1993). This index ranges from 1 (low concern) to 5 (high concern); scores for each species are based on means of seven criteria values. Birds grouped together as 'area sensitive' are those demonstrated in the majority of other studies to prefer large forest tracts (Best et al. 1996). All raptors, nightjars, late spring vagrants and flyovers were omitted from these analyses.

We calculated an abundance index for birds in each management assemblage (separately for 1995, 1996) by first calculating the total number of bird observations (inside a 50 m radius circle) per census point, then calculating the mean number of detections per census point (across temporal replicates) at each site. Similarly, we determined the species richness of birds in each management assemblage (separately for 1995, 1996) by first calculating the total number of bird species detected per census point (no distance restriction), then calculating the mean number of bird species detected per census point (across temporal replicates) for each site.

We also conducted multiple regression analyses to determine whether the abundance and species richness of forest birds were related to the evaluation criteria (Tree Size, Tree Structure, Shrub Structure, Canopy Dominance, Subcanopy Dominance, Shrub Dominance) used to construct ($\overline{Q}$). Prior to conducting these analyses, we conducted principal components analysis (PCA) on the values obtained for the six individual criteria (mean values for each site) to eliminate collinearity. In subsequent regression analyses, we used these components (PCA1, PCA2, PCA3) as independent variables, which we interpreted via examination of the eigenvectors associated with the original variables.

Results

Analysis of Correlation Between Forest Area and Quality

There was little evidence of correlation between the quality ($\bar{Q}$) and area (A) of our study sites ($r = 0.14$, $p < 0.35$). Subsequent multiple regression analyses were therefore not hampered by problems of collinearity between these two independent variables.

Influence of Forest Quality/Area on Avian Abundance and Species Richness

Forest quality ($\bar{Q}$) was correlated with the abundances of three bird groups: permanent residents (-), cavity nesters (-) and area sensitive birds during a single year of this study (no relationship was detected for two years). Large forest sites had higher abundance of ground nesters (1995, 1996) but lower abundances of total birds (1995), permanent residents (1995, 1996), cavity nesters (1995) and shrub nesters (1995).

Forest quality ($\bar{Q}$) was correlated with the species richnesses of five bird groups, including high management concern species, short-distance migrants (-) and ground nesters (-) in both 1995 and 1996 (Table 2). In addition, cavity nesters and permanent residents had higher species richness in low quality forests in 1996. Large forest sites attracted more species of total birds (1996), neotropical migrants (1996), ground nesters (1996), high management concern species (1995, 1996) and area sensitive birds (1996) than small forest sites.

We consider all other detected relationships involving effects of forest quality and/or forest area on bird abundance to be tentative because they were observed for only one year.

Principal Components Analysis of Evaluation Criteria

Three components derived from principal component analysis were sufficient to account for 74% of the total variance of the six original criteria used to construct the natural quality index (Table 3). The first component, PCA1 (37% of total variance), represents overall forest quality because all of the original variables have high positive loadings in the associated eigenvector. The second component, PCA2 (21% of total variance) is a proxy for forest structure because high loadings on Tree Size and Tree Structure contrast with a high loading for Shrub Structure. Finally, the third component, PCA3 (15% of total variance), summarizes both structural and floristic information. It contrasts Canopy Dominance (large positive loading) with three other variables: Tree Structure, Shrub Structure and Shrub Dominance (large negative loadings).

Influence of Evaluation Criteria on Avian Abundance and Species Richness

We found significant relationships between PCA1 (overall natural quality) and the abundance of three bird groups (permanent residents (-), tree nesters and area sensitive birds (1996); none were detected during both years of this study (Table 4). PCA2 (structure) was correlated with the abundance of only one bird group (permanent residents (-)) but this relationship was detected only in 1996. We detected no relationships between the abundance of any bird group and PCA3 (structure and floristics).

Significant relationships existed between the species richnesses of eight bird groups with PCA1 (overall natural quality); those involving the species richnesses of short-distance migrants (-), ground nesters (-) and high management concern species (+) were detected during both years of this study (Table 4). No relationship was detected for the species richness of any bird group with PCA2 (forest structure); the species richness of only one bird group (ground nesters, 1996) was correlated with PCA3 (structure and floristics).

In these analyses, the abundances of cavity nesters (-) and ground nesters, and the species richness of high management concern species, were correlated with forest area (A) in 1995 and 1996 (Table 4). We detected seven other relationships between the abundance and/or species richness of bird groups with forest area (A) for a single year of this study (Table 4).

Discussion

It is not surprising that the species richness (mean number of birds detected per census point at each site) of total birds and neotropical migrants was not consistently related to forest quality ($\overline{Q}$) in northeast Iowa (Table 2). Obviously, "total birds" consists of both generalists and specialists; *en masse*, one would expect to encounter these in a wide range of forest types that span the spectrum of forest quality. Although "neotropical migrants" are currently of great management concern, this bird assemblage also encompasses both forest interior specialists (e.g., cerulean warbler, veery) and other species (e.g., house wren, blue-winged warbler, rose-breasted grosbeak, indigo bunting) known to utilize shrubby, successional habitat for nesting and/or foraging, at least occasionally (Table 1, Jackson et al. 1995). On the other hand, the negative relationship between forest quality and the species richness of short distance migrants (1995, 1996) and permanent residents (1996) suggests that the majority of these birds frequent successional forests. Likewise, Blake and Karr (1987) found that the species richness of permanent residents and short-distance migrants in Illinois woodlots was related to the presence of shrubby vegetation.

Analyses for relationships between forest quality ($\overline{Q}$) and the abundance and species richness of bird groups defined by nest substrate revealed only one clear correlation: a negative relationship between forest quality and the species richness of ground nesters (Table 2). "Highly natural" forests, as rated by our rating system, would tend to have open understories with limited ground cover by shrubs. It may be that some ground nester species in northeast Iowa prefer to build their nests in lower quality forests because these tend to have shrubby understories for potential nest concealment. The Eastern towhee, for instance, typically places its nest on or near ground under or in small bushes (Harrison, 1975). On the other hand, forest quality ($\overline{Q}$) was not related to the species richness or abundance of birds in any other group defined by nest substrate (cavity, shrub, tree) in both years. It is likely that habitat usage by birds in these groups are influenced by other crucial behaviors besides nest placement; e.g., they might utilize other foliage layers (i.e., shrub, tree) while foraging (Martin 1991, Block et al. 1995). For example, four different food substrates (air, ground, tree, flowers) are utilized by the tree nesting species encountered in this study (Table 1), thus demonstrating the use of multiple forest strata by birds which nest in trees.

Our finding that high management concern birds are most diverse in high quality forests suggests that mature forest vegetation in northeast Iowa, though scarce, is important wildlife habitat. These bird species may have evolved preferences for particular foliage structural attributes and/or woody plant species available in "high quality" forests but not in successional habitat. For instance, Holmes and Robinson (1981) showed that the occurrence of some bird species in northern hardwood forests is linked to preferences for particular tree species that provide abundant food resources and/or unique structural attributes that differentially influence foraging behavior. Likewise, May (1982) found that specialist feeding guilds were more prevalent in older forests than in younger forests in Virginia. May attributed this pattern to the addition of several insectivorous guilds in late successional stages. Similar phenomena may explain why high management concern species in northeast Iowa are attracted to mature forests.

An obvious question that arises when one inspects our results is why the abundance of birds in the high priority bird group did not also vary predictably with forest quality. Two possible explanations come to mind. First, it might have been that total numbers of these birds were too small to allow changes in abundance to be detected by our statistical tests. This is unlikely given that one bird species in this group, the eastern wood pewee, was among the most frequently detected birds in our study (Chapter 3). A more plausible explanation also involves the eastern wood pewee. The high abundance of the eastern wood pewee in northeast Iowa forests indicate that it is a habitat generalist (as was reported for this species by Bond (1957) for upland forests in southern Wisconsin). As such, the apparent non-correlation between the abundance of high priority forest birds and forest quality may really reflect the ubiquity and sheer numbers of eastern wood pewees.

Why is the "Naturalness" Concept Relevant?

Is "natural quality" a biologically valid concept? By our definition, natural quality summarizes the overall condition of a forest with respect to tree size, foliage distribution and dominance patterns exhibited by woody plant species in canopy, subcanopy and shrub layers. Individual birds are known to use a variety of cues when selecting habitat (structure, plant species, topography, etc.) but it is uncertain whether these cues interact independently, hierarchically or synergistically (Cody 1985). Of course, habitat isn't actively selected by a "bird community" but it is interesting nevertheless to ask whether the factors that influence bird community composition operate independently or interactively. In our analyses (Table 4), we discovered relationships (1995 and/or 1996) between the species richnesses of eight bird groups and PCA1 (a proxy for overall quality) but few relationships with two other principal components (PCA2, PCA3) that represent specific vegetation characteristics. In our view, this is evidence that overall "natural quality" may better explain local species richness patterns of forest birds than any single forest attribute.

Management Recommendations

Although conversion of Iowa forests to pastures has declined (Jungst et al. 1998), it is likely that harvesting of valuable tree species (i.e., oak, walnut) will continue. Thompson et al. (1995) present a strategy for forest management in the Midwest that considers both conservation of neotropical migratory birds and future resource utilization by humans. These authors stressed that many bird species that breed in mature forests would benefit from large blocks of unfragmented forest reserved from timber harvest and other anthropogenic disturbances (management at the landscape scale) and recommend that timber harvest be concentrated in more fragmented forests within a given region.

In our study, we determined that forest birds of highest management concern are most diverse in natural forests that have been long withheld from recent logging and pasturing (Tables 2, 4). We believe that maintenance of suitable habitat for utilization by these bird species is a reasonable goal for management of northeast Iowa forests at this time. Given the preponderance of successional/disturbed forest habitat in this region, we recommend that existing "natural" forests be set aside from human impacts and suggest that other, mid-successional forests be allowed to recover and thus provide habitat for future generations of these habitat specialists.

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Table 1. Bird species detected during point counts in 44 study sites in northeast Iowa forests (1995-1996). N = number of observations (inside a 50 m radius circle) during both years. Life history characteristics, conservation status and area sensitivity are as given in Best et al. (1996). Birds detected fewer than ten times are not listed.

Species	N	Migratory Status[1]	Nest Substrate[2]	Food Substrate[3]	PIF Prioritizations[4]	Area Sensitivity[5]
Brown-headed cowbird (*Molothrus ater*)	628	sho	--	g	--	(+)
Blue-gray gnatcatcher (*Polioptila caerulea*)	556	neo	t	t	2.43	++
Eastern wood-pewee (*Contopus virens*)	484	neo	t	a	3.29	+
Red-eyed vireo (*Vireo olivaceus*)	482	neo	t	t	2.14	+
American redstart (*Setophaga ruticilla*)	373	neo	s	s	2.86	+
House wren (*Troglodytes aedon*)	317	neo	c	s	1.57	(?)
Ovenbird (*Seiurus aurocapillus*)	311	neo	g	g	3.14	++
Indigo bunting (*Passerina cyanea*)	292	neo	s	s	2.86	(-)
White-breasted nuthatch (*Sitta carolinensis*)	285	per	c	b	--	+
Northern cardinal (*Cardinalis cardinalis*)	255	per	s	g	--	(-)
Great crested flycatcher (*Myiarchus crinitus*)	250	neo	c	a	3.29	+
Blue jay (*Cyanocitta cristata*)	242	per	t	g	--	(+)
Gray catbird (*Dumetella carolinensis*)	233	neo	s	g	2.86	(-)
Black-capped chickadee (*Poecile atricapillus*)	205	per	c	s	--	(+)
Red-bellied woodpecker (*Melanerpes carolinus*)	183	per	c	b	--	+
Hairy/downy woodpecker (*Picoides villosus/pubescens*)	165	per	c, c	b, b	--	+
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	163	neo	s	t	3.14	+
Yellow-throated vireo (*Vireo flavifrons*)	163	neo	t	t	3.00	+
Scarlet tanager (*Piranga olivacea*)	153	neo	t	t	3.00	++
American goldfinch (*Carduelis tristis*)	142	sho	s	s	--	(?)
American robin (*Turdus migratorius*)	141	sho	t	g	--	(-)
Acadian flycatcher (*Empidonax virescens*)	129	neo	t	a	3.43	++
Eastern towhee (*Piplio erythrophthalamus*)	112	sho	g	g	--	-
Baltimore oriole (*Icterus galbula*)	102	neo	t	t	2.86	(+)
Tufted titmouse (*Baeolophus bicolor*)	97	per	c	s	--	+
Wood thrush (*Hylocichla mustelina*)	73	neo	s	g	3.57	++
American crow (*Corvus brachyrhynchos*)	70	per	t	g	--	(+)
Chipping sparrow (*Spizella passerina*)	69	neo	s	g	1.86	(-)
Red-winged blackbird (*Agelaius phoeniceus*)	48	sho	g	g	--	(-)

Table 1 (continued)

Species	N	Migratory Status[1]	Nest Substrate[2]	Food Substrate[3]	PIF Prioritizations[4]	Area Sensitivity[5]
Common yellowthroat (*Geothlypis trichas*)	47	neo	g	s	2.29	(?)
Yellow warbler (*Dendroica petechia*)	47	neo	s	s	1.57	(+)
Yellow-bellied sapsucker (*Sphyrapicus varius*)	37	sho	c	b	--	+
Cerulean warbler (*Dendroica cerulea*)	36	neo	t	t	4.29	++
Ruby-throated hummingbird (*Archilochus colubris*)	36	neo	t	f	2.57	(+)
Song sparrow (*Melospiza melodia*)	35	sho	s	s	--	(?)
Blue-winged warbler (*Vermivora pinus*)	33	neo	g	s	3.57	?
Red-headed woodpecker (*Melanerpes erythrocephalus*)	32	sho	c	a	--	(+)
Pileated woodpecker (*Dryocopus pileatus*)	31	per	c	b	--	+
Common grackle (*Quiscalus quiscula*)	27	sho	t	g	--	0
Least flycatcher (*Empidonax minimus*)	25	neo	t	a	2.71	++
Field sparrow (*Spizella pusilla*)	23	sho	g	g	--	(+)
Warbling vireo (*Vireo gilvus*)	23	neo	t	t	2.57	+
Yellow-billed cuckoo (*Coccyzus americanus*)	22	neo	s	s	3.29	+
Cedar waxwing (*Bombycilla cedrorum*)	21	sho	t	a	--	*
Eastern phoebe (*Sayornis phoebe*)	21	sho	b	a	--	+
Northern flicker (*Colaptes auratus*)	19	sho	c	g	--	(+)
Louisiana waterthrush (*Seiurus motacilla*)	17	neo	b	sh	3.00	++
Veery (*Catharus fuscescens*)	17	neo	g	g	3.29	++
Brown thrasher (*Toxostoma rufum*)	12	sho	s	g	--	(?)
Chestnut sided warbler (*Dendroica pensylvanica*)	12	neo	s	*	3.57	?
Mourning Dove (*Zenaida macroura*)	11	sho	t	g	--	(?)

[1] Migratory Status: neo = neotropical; per = permanent resident; sho = short-distance migrant.

[2] Nest Substrate: c = cavity; g = ground; s = shrub; t = tree; b = streambanks; bu = man-made structures.

[3] Food Substrate: a = air; b = bark; f = flowers; g = ground; s = shrub; sh = shore; t = tree.

[4] PIF (Partners' in Flight) Prioritizations: Values range from 1-5. See text for more details..

Table 1. (continued)

[5] Area Sensitivity: ++ = consistently positive area sensitive; + = primarily positive area sensitivity but some studies detected none; (+) = primarily no area sensitivity but some studies detected positive area sensitivity; 0 = consistently no area sensitivity; (-) = primarily no area sensitivity but some studies detected negative area sensitivity; - = primarily negative area sensitivity but some studies detected none; (?) = area sensitivity unknown because of contradictory results; ? = area sensitivity unknown because it has not been studied

Table 2. Multiple regression analyses of avian a) abundance and b) species richness on site quality ($\overline{Q}$) and total forest area (A). Species richness was determined as the mean number of detections (no distance restriction) per census point at each site. Forest area (A) is the total amount of forest (ha) within a 1-km extension of the political boundaries of each site. B = parameter estimate of each independent variable in the regression equation; SE = standard error of B. Bird categories described in text. '*' indicates $p \le 0.10$; '**' indicates $p \le 0.05$; '***' indicates $p \le 0.01$.

I) Avian Abundance

		Forest Quality ($\overline{Q}$)			Forest Area (A)		
	r^2	B	SE	P > |T|	B	SE	P > |T|
A) Total Birds							
Total (1995)	0.09	-0.28	0.40	0.49	-0.0058	0.0032	0.08*
Total (1996)	< 0.01	0.01	0.31	0.98	-0.0005	0.0025	0.85
B) Migratory Status							
Neotropical (1995)	0.05	0.11	0.30	0.36	-0.0033	0.0023	0.17
Neotropical (1996)	0.04	0.30	0.23	0.21	0.0003	0.0018	0.89
Perm. Residents (1995)	0.12	-0.24	0.18	0.18	-0.0024	0.0014	0.09*
Perm. Residents (1996)	0.11	-0.25	0.12	0.04**	-0.00061	0.00093	0.51
Short-Dist. Migr. (1995)	0.04	-0.16	0.13	0.23	-0.0000	0.0010	0.99
Short-Dist. Migr. (1996)	< 0.01	-0.04	0.12	0.73	-0.00013	0.00090	0.88
C) Nest Substrate							
Cavity (1995)	0.18	-0.31	0.18	0.09*	-0.0031	0.0014	0.03**
Cavity (1996)	0.11	-0.06	0.11	0.60	-0.00184	0.00089	0.05**
Ground (1995)	0.19	-0.056	0.068	0.42	0.00167	0.00054	< 0.01***
Ground (1996)	0.17	-0.055	0.065	0.41	0.00144	0.00051	< 0.01***
Shrub (1995)	0.07	-0.02	0.18	0.89	-0.0024	0.0014	0.09*
Shrub (1996)	0.04	-0.06	0.18	0.72	-0.0015	0.0014	0.27
Tree (1995)	0.03	0.13	0.19	0.48	-0.0014	0.0015	0.35
Tree (1996)	0.09	0.20	0.14	0.15	0.0013	0.0011	0.22
D) Other							
PIF (1995)	0.06	0.15	0.13	0.27	0.0010	0.0010	0.33
PIF (1996)	0.07	0.11	0.13	0.38	0.00145	0.00098	0.15
Area Sensitive (1995)	0.02	0.22	0.23	0.35	-0.0009	0.0018	0.62
Area Sensitive (1996)	0.13	0.34	0.20	0.09*	0.0023	0.0016	0.15

Table 2. (continued)

II) Avian Species Richness

	r^2	Forest Quality ($\overline{Q}$) B	SE	P > |T|	Forest Area (A) B	SE	P > |T|
A) Total Birds							
Total (1995)	0.05	-0.23	0.20	0.26	0.0015	0.0016	0.34
Total (1996)	0.12	-0.22	0.16	0.17	0.0025	0.0012	0.05**
B) Migratory Status							
Neotropical (1995)	0.07	0.21	0.13	0.13	0.0007	0.0010	0.51
Neotropical (1996)	0.18	0.15	0.12	0.24	0.0025	0.0010	0.02**
Perm. Residents (1995)	0.06	-0.13	0.08	0.11	0.00015	0.00065	0.82
Perm. Residents (1996)	0.12	-0.146	0.070	0.04**	-0.00042	0.00055	0.44
Short-Dist. Migr. (1995)	0.17	-0.31	0.10	< 0.01***	0.00077	0.00084	0.37
Short-Dist. Migr. (1996)	0.15	-0.228	0.086	0.01***	0.00046	0.00067	0.50
C) Nest Substrate							
Cavity (1995)	0.03	-0.096	0.099	0.34	-0.00020	0.00078	0.80
Cavity (1996)	0.10	-0.140	0.073	0.06*	-0.00044	0.00058	0.45
Ground (1995)	0.09	-0.102	0.055	0.07*	0.00040	0.00043	0.36
Ground (1996)	0.27	-0.128	0.049	0.01***	0.00123	0.00038	< 0.01***
Shrub (1995)	0.06	-0.127	0.087	0.15	0.00049	0.00068	0.47
Shrub (1996)	0.06	-0.060	0.085	0.49	0.00107	0.00067	0.12
Tree (1995)	0.03	0.066	0.088	0.50	0.00052	0.00069	0.45
Tree (1996)	0.08	0.134	0.077	0.09*	0.00032	0.00060	0.60
D) Other							
PIF (1995)	0.15	0.146	0.086	0.10*	0.00124	0.00067	0.07*
PIF (1996)	0.23	0.139	0.076	0.07*	0.00161	0.00059	0.01**
Area Sensitive (1995)	0.10	0.21	0.14	0.14	0.0014	0.0011	0.20
Area Sensitive (1996)	0.18	0.10	0.10	0.36	0.00233	0.00086	< 0.01***

Table 3. Eigenvectors for principal components derived from criteria used to evaluate natural quality of forest vegetation. Variables are described in the Methods.

	Principal Components		
	PCA1	PCA2	PCA3
Evaluation Criteria			
TREE SIZE	.33	.52	.01
TREE STRUCTURE	.22	.65	-.28
SHRUB STRUCTURE	.39	-.54	-.36
CANOPY DOMINANCE	.38	-.04	.80
SUBCANOPY DOMINANCE	.49	-.08	.19
SHRUB DOMINANCE	.56	-.08	-.35
Eigenvalue	2.2	1.4	.87
Variance Explained (%)	37	23	14
Cumulative Variance Explained (%)	37	60	75

Table 4. Regression analyses of a) bird abundance and b) bird species richness on site area (A) and three principal component (PCA1, PCA2, PCA3) variables derived from six natural quality criteria. Species richness was determined as the mean number of detections (no distance restriction) per census point at each site. Forest area (A) is the total amount of forest (ha) within a 1-km extension of the political boundaries of each site. B = parameter estimate for each independent variable in the regression equation; SE = standard error of B. Bird categories described in text. '*' indicates p ≤ 0.10; '**' indicates p ≤ 0.05; '***' indicates p ≤ 0.01.

I) Abundance

	PCA1			PCA2			PCA3			A		
	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|
A) Total Birds												
Total(1995)	-0.25	0.59	0.68	-0.14	0.74	0.85	-0.30	0.94	0.75	-0.0058	0.0033	0.08*
Total(1996)	0.15	0.45	0.75	-0.01	0.56	0.98	-0.63	0.72	0.39	-0.0006	0.0025	0.81
B) Migratory Status												
Neotropical Migrant (1995)	0.30	0.43	0.49	0.15	0.54	0.78	0.19	0.69	0.78	-0.0034	0.0024	0.16
Neotropical Migrant (1996)	0.53	0.34	0.12	0.19	0.42	0.66	-0.26	0.53	0.62	0.0000	0.0018	0.98
Permanent Resident (1995)	-0.35	0.26	0.17	-0.09	0.32	0.77	-0.32	0.40	0.44	-0.0024	0.0014	0.10*
Permanent Resident (1996)	-0.35	0.17	0.04**	-0.37	0.21	0.08*	-0.07	0.26	0.80	-0.00043	0.00092	0.64
Short-Distance Migrant (1995)	-0.20	0.18	0.28	-0.22	0.23	0.34	-0.20	0.29	0.50	0.0001	0.0010	0.95
Short-Distance Migrant (1996)	-0.03	0.16	0.87	0.17	0.21	0.42	-0.31	0.26	0.25	-0.0003	0.0009	0.78

Table 4. (continued)

I) Abundance

	PCA1			PCA2			PCA3			A		
	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|
C) Nest Substrate												
Cavity(1995)	-0.40	0.26	0.13	-0.15	0.32	0.65	-0.57	0.41	0.18	-0.0031	0.0014	0.03**
Cavity(1996)	-0.06	0.16	0.71	-0.22	0.20	0.28	-0.30	0.26	0.25	-0.00179	0.00090	0.05**
Ground(1995)	-0.100	0.095	0.30	0.16	0.12	0.17	0.23	0.15	0.13	0.00164	0.00052	< 0.01***
Ground(1996)	-0.065	0.093	0.49	0.11	0.12	0.33	0.18	0.15	0.22	0.00139	0.00051	< 0.01***
Shrub(1995)	0.01	0.26	0.96	-0.11	0.32	0.74	0.20	0.41	0.63	-0.0023	0.0014	0.11
Shrub(1996)	-0.06	0.26	0.80	-0.01	0.32	0.99	-0.18	0.41	0.66	-0.0016	0.0014	0.28
Tree(1995)	0.28	0.27	0.31	-0.05	0.34	0.88	-0.10	0.43	0.81	-0.0015	0.0015	0.34
Tree(1996)	0.34	0.20	0.09*	-0.02	0.24	0.93	-0.15	0.31	0.64	0.0012	0.0011	0.25
D) Other												
PIF(1995)	-0.42	0.55	0.45	-0.34	0.69	0.63	-1.19	0.88	0.18	-0.0066	0.0031	0.04**
PIF(1996)	-0.02	0.41	0.96	-0.32	0.51	0.53	-0.86	0.65	0.19	-0.0014	0.0023	0.52
Area Sensitive (1995)	0.42	0.34	0.22	0.36	0.42	0.40	0.24	0.53	0.65	-0.0011	0.0018	0.54
Area Sensitive (1996)	0.60	0.29	0.04**	0.24	0.36	0.51	-0.01	0.46	0.99	0.0021	0.0016	0.20

Table 4. (continued)

II) Species Richness

	PCA1			PCA2			PCA3			A		
	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|
A) Total Birds												
Total(1995)	-0.23	0.30	0.45	-0.01	0.37	0.99	0.13	0.47	0.78	0.0015	0.0016	0.38
Total(1996)	-0.28	0.23	0.22	0.21	0.28	0.45	-0.12	0.36	0.74	0.0024	0.0013	0.06*
B) Migratory Status												
Neotropical Migrant (1995)	0.37	0.19	0.06*	0.07	0.24	0.76	0.05	0.30	0.88	0.0006	0.0010	0.58
Neotropical Migrant (1996)	0.28	0.18	0.13	0.18	0.22	0.42	0.11	0.28	0.71	0.00234	0.00099	0.02**
Permanent Resident (1995)	-0.18	0.12	0.14	-0.05	0.15	0.74	-0.16	0.19	0.42	0.00016	0.00067	0.82
Permanent Resident (1996)	-0.223	0.098	0.03**	-0.11	0.12	0.38	-0.23	0.15	0.14	-0.00038	0.00054	0.49
Short-Distance Migrant (1995)	-0.42	0.16	0.01***	-0.05	0.19	0.80	0.23	0.25	0.36	0.00081	0.00086	0.35
Short-Distance Migrant (1996)	-0.35	0.12	< 0.01***	0.13	0.15	0.39	0.01	0.20	0.96	0.00043	0.00068	0.53

Table 4. (continued)

II) Species Richness

	PCA1			PCA2			PCA3			A		
	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|	B	SE	P > |T|
C) Nest Substrate												
Cavity(1995)	-0.11	0.15	0.46	-0.05	0.18	0.77	-0.08	0.23	0.74	-0.00020	0.00081	0.80
Cavity(1996)	-0.21	0.10	0.05**	-0.11	0.13	0.40	-0.21	0.17	0.22	-0.00040	0.00058	0.50
Ground(1995)	-0.159	0.079	0.05**	0.086	0.099	0.39	-0.02	0.13	0.90	0.00038	0.00044	0.40
Ground(1996)	-0.185	0.067	< 0.01***	0.124	0.083	0.14	0.20	0.11	*0.06	0.0012	0.0004	< 0.01***
Shrub(1995)	-0.15	0.12	0.23	-0.01	0.16	0.95	0.17	0.20	0.39	0.00050	0.00070	0.48
Shrub(1996)	-0.06	0.12	0.64	0.09	0.15	0.57	0.08	0.20	0.67	0.00102	0.00069	0.15
Tree(1995)	0.13	0.13	0.33	-0.10	0.16	0.55	-0.18	0.20	0.39	0.00052	0.00070	0.46
Tree(1996)	0.20	0.11	0.08*	-0.04	0.14	0.77	-0.28	0.17	0.12	0.00030	0.00060	0.62
D) Other												
PIF(1995)	0.24	0.12	0.06*	0.13	0.15	0.39	0.16	0.19	0.42	0.00117	0.00068	0.09*
PIF(1996)	0.22	0.11	0.04**	0.20	0.13	0.15	0.12	0.17	0.47	0.00150	0.00059	0.01**
Area Sensitive (1995)	0.36	0.20	0.09*	0.13	0.25	0.60	-0.06	0.32	0.86	0.0013	0.0011	0.25
Area Sensitive (1996)	0.17	0.16	0.28	0.27	0.19	0.18	0.08	0.25	0.76	0.00219	0.00086	0.01***

CHAPTER 6. THE FOREST AVIFAUNA OF NORTHEAST IOWA: VEGETATION AND LANDSCAPE RELATIONSHIPS

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ABSTRACT

We studied the influence of vegetation and landscape characteristics on the forest avifauna of northeast Iowa in forest sites ranging in size between 32 ha and 486 ha. Both old-growth and recently logged/pastured forests were included. Birds were censused using point counts, and woody vegetation in canopy, subcanopy and shrub layers was surveyed using standard releve methods. We tested for the influence of three vegetation variables (treecover, shrubcover, forest type) on the abundance (mean number of detections per census point at each study site) and species richness (mean number of bird species detected per census point at each study site) of birds. Furthermore, we tested for relationships with three landscape variables (forest area, mean distance between forest patches, forest shape) measured within a 1-km extension of the political boundaries of each site. For these analyses, we divided birds into groups determined by migratory status, preferred nest substrate, high management concern and area sensitivity (+). We found evidence suggesting that bird community composition in northeast Iowa shifts along a vegetation composition gradient, with many bird groups more abundant and/or species rich in mesic forests dominated by *Acer saccharum*, *Quercus rubra* and *Tilia americana*. However, all relationships involving vegetation compostion were detected for a single year and are hence tentative. Several relationships were detected during both 1995 and 1996, including a correlation between the species richness (i.e., mean number of bird species

detected per census point at each site) of high management concern bird species and forest area. This result underscores the importance of large forest tracts as potential habitat for conservative bird species.

INTRODUCTION

The abundance and species richness of forest birds in Midwestern forests are often correlated with landscape and/or vegetation characteristics. Numerous studies have demonstrated that the number of total bird species occurring in a forest patch increases with forest area (Bond, 1957; Ambuel and Temple, 1983; Blake and Karr, 1987). As for abundance (number of detections per unit area) of individual bird species, both vegetation parameters and forest area are often needed to explain patterns of variation (Ambuel and Temple, 1983; Blake and Karr, 1987). Recently disturbed (i.e., logged, pastured) forests have usually been excluded from most of these studies, even though they comprise the majority of forest cover in much of the Midwest.

Disturbed forests often differ markedly from old-growth forests with respect to structural characteristics and plant species composition. Specifically, forests which have been recently logged and/or grazed often have poorly differentiated overstory layers and dense shrub layers relative to mature forests. Furthermore, the dominant woody plant species in canopy, subcanopy and shrub layers of recently disturbed forests are often not the same as those found in the corresponding layers of old-growth forests (Chapter 4). Both habitat structure and plant species composition are known to influence habitat selection by birds (MacArthur and MacArthur, 1961; Holmes and Robinson, 1981; Robinson and Holmes, 1984; Cody, 1985); hence, forest management practices have the potential to influence the composition of forest bird communities.

Here, we investigate the influence of vegetation and landscape on summer bird communities in northeast Iowa across a broad spectrum of forest types ranging from forest preserves to recently logged/pastured forests. Our inclusion of disturbed forests in this study was essential because such forests are a dominant part of the universe from which birds select habitat in northeast Iowa. We focused on habitat associations of multi-species bird groups (defined by migratory class, nest substrate, level of management concern and area sensitivity) because forest management is often geared towards conservation of these "management assemblages" (Block et al., 1995). (In this paper, the term 'bird' refers collectively to cuckoos, hummingbirds, passerines and woodpeckers)

Use of forest patches by birds is also influenced by the landscape characteristics such as total forest area (Faaborg *et al.*, 1995). However, the amount of core forest area (i.e., interior forest not in contact with forest boundaries) is often a better predictor of bird species occurrence than total forest area (Temple, 1986; Faaborg *et al.*, 1985). Forest shape also influences habitat utilization by some bird species because irregularly shaped forests have abundant edge habitat known to attract detrimental predators and nest parasites (Martin 1981; Blake 1983; Faaborg *et al.*, 1995). And, the relative proximity of forest patches can affect bird community composition because some birds avoid isolated forest patches (Opdam *et al.*, 1994, 1995). Therefore, we considered the influence of several forest cover attributes (i.e., total forest area, total core area, shape, degree of isolation) in our analyses of bird-landscape relationships.

STUDY AREA

This study was conducted in six northeast Iowa counties: Allamakee, Clayton, Delaware, Dubuque, Fayette and Winneshiek (Fig. 1). Although this corner of Iowa was predominantly forested (approximately 59% forest cover) in the middle of the last century (Anderson, 1996), the majority of this forest cover has been reduced to forest fragments (currently, about 19% forest cover; Fig. 1). Northeast Iowa forests belong to the Central Hardwoods forest region (Braun, 1964) and have been described by Cahayla-Wynne and Glenn-Lewin (1978). Oak (*Quercus alba*, *Q. ellipsoidalis*, *Q. macrocarpa*, *Q. rubra*), sugar maple (*Acer saccharum*) and American basswood (*Tilia americana*) are typical canopy dominants on upland terrain; floodplain forests usually have black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*) and elm (*Ulmus americana*, *U. rubra*) dominant in their canopies.

A small number of northeast Iowa forests (state preserves, state parks, forest reserves) have been protected for many years and have closed canopies, well differentiated canopy and subcanopy layers, diffuse shrub layers and high native plant diversity. However, the majority of northeast Iowa forests have been logged and/or grazed within the past fifty years. These forests are characterized by reduced overstory stratification and shrubby understories dominated by prickly shrub species such as gooseberry (*Ribes missouriense*), prickly ash (*Zanthoxylum americanum*), black raspberry (*Rubus occidentalis*) and blackberry (*Rubus allegheniensis*).

METHODS

Site Selection

We selected 44 study sites (32-486 ha) in northeast Iowa for use in this study. These included 17 public lands (state parks, state preserves, wildlife management areas) and 27 privately owned forests. Among the privately owned sites were forests that had recently been logged and/or grazed as well as others set aside in forest reserve programs. We did not include forests from the Mississippi River floodplain because the avifauna of this ecosystem has already been studied (Knutson *et al.*, 1996; Knutson and Klaas, 1997).

Most forests in northeast Iowa are connected to other forests by at least a narrow corridor of trees. Hence, our study sites were not isolated “patches” in the sense of Hanski and Simberloff (1997). Nonetheless, most of our study sites were surrounded by cropfields or open pasture along the majority (> 80%) of their borders.

We allocated bird census points to each of our 44 study sites in proportion to area using a stratified random sampling scheme. We marked the center of each bird census point with two parallel bands of white paint and pink flagging and placed them at least 50 m from the forest edge so that the entire point (50 m radius) would be within the forest. Census points were situated at least 250 m apart to minimize the possibility of double counting individual birds during a census (Ralph *et al.*, 1993). Our smallest study site (32 ha) had two census points and the largest site (486 ha) had twelve such points. We located bird census points in a variety of topographic positions including upland habitats (ridgetops, slopes, ravines), lowlands floodplains and narrow wooded creek bottoms.

Bird Census Data

We conducted bird censuses between May 30 and July 15 in both 1995 and 1996. All field technicians working on the project received two weeks of training in bird song recognition immediately prior to conducting these censuses. We followed the protocol established by Ralph *et al.* (1993) for bird census, which always took place on calm, rainless mornings from sunrise to 10:00 AM. We censused all 189 bird census points three times each season at approximately two week intervals, with replicate censuses at each point conducted by different observers to minimize observer bias. Each point count was 10 minutes in duration. We recorded all birds detected during the census as occurring either inside or outside a 50 m radius circle centered on the marked tree.

For each forest site, we calculated mean values of bird abundance per point and species richness per point. Our analyses were conducted for total birds as well as for "management assemblages" determined by migratory class (neotropical migrants, permanent residents, short-distance migrants), nest substrate (cavity, ground, shrub, tree), level of management concern and area sensitivity. We assigned birds to each migratory and nest substrate assemblage based on categorizations by Best *et al.* (1996). Bird species grouped in the high management concern category are those species (neotropical migrants only) with high values (≥ 3.0) for a conservation priority index (PIF) developed by the U.S. Fish and Wildlife Service (Thompson *et al.*, 1993). This index ranges from 1 (low concern) to 5 (high concern) with values for each species based on the mean of seven criteria values. The "area sensitive" assemblage included all bird species reported to be area sensitive in the majority of previous studies (Best *et al.* 1996). All raptors, nightjars, late spring vagrants and flyovers were excluded from consideration.

The abundance of birds for each management assemblage was calculated as the mean number of bird observations per point at each site. The total observations of bird detections (inside 50 m) at each census point was summed over the three replicates, and the mean number of detections per census point was calculated for each site (separately for 1995 and 1996).

The species richness of each management assemblage was calculated as the mean number of bird species detected per point at each site. The total number of bird species detected at each census point was summed over the three replicates (no distance restriction), and the mean number of bird species detected per census point was calculated at each site (separately for 1995 and 1996).

Vegetation Survey Data

Standard releve methods (Mueller-Dombois and Ellenberg, 1974; Chapter 4) were used to survey the woody vegetation at each study site. We allocated 0.10 ha circular survey plots within each site (independent of bird census points) in proportion to area such that one 0.10 ha plot was surveyed for every 20 ha of forest area, plus two additional plots (to increase the number of plots in small forests). Prior to survey, we marked all survey plots on a topographic map of each forest to enable representation of all available topographic aspects (e.g., ridge, slope, bottomland).

Our survey methodology assumes that woody vegetation (excluding vines) in northeast Iowa occurs in three layers: a canopy (all trees with canopy exposed to the sky); a subcanopy (all trees greater than 2 m in height and underneath the canopy or in a canopy gap) and a shrub layer (all woody vegetation between 0.5 m and 2 m in height). At each survey plot, we recorded the total cover provided by woody species (excluding vines) in each of these layers. Then, we recorded the component woody species occurring in these three layers within broad cover classes.

To characterize the vertical stratification of foliage at each study site, we calculated mean values of canopy cover, subcanopy cover and shrub cover. After testing for correlation among these variables (i.e., mean values), we reduced the original three variables to a smaller set of uncorrelated variables using principal component analysis (PCA).

To summarize the species composition of the canopy at each site, we calculated importance values (I.V.) for each woody species as the sum of relative frequency and relative dominance at each site. For each species x at a given site:

$$\text{frequency}(x) = \text{(number of plots containing x)}$$

$$\text{relative frequency}(x) = \text{frequency}(x) \,/\, \text{(total frequency of all species)}$$

$$\text{dominance}(x) = \text{(total canopy cover provided by x in all plots)}$$

$$\text{relative dominance}(x) = \text{dominance}(x) \,/\, \text{(total dominance of all species)}$$

$$\text{I.V.}(x) = (\text{relative frequency}(x) + \text{relative dominance}(x)) \times 100$$

Following calculation of importance values for each canopy species at each site, we summarized these data using detrended correspondence analysis (DCA). DCA is an ordination technique that arranges plant community data into a low dimensional space so that similar entities are close together and dissimilar entities are far apart (Gauch 1982). We graphed all 44 study sites along the first two DCA axes to allow visualization of the ordination. We also created overlay diagrams for six major tree species (*Acer saccharum*, *Tilia americana*, *Quercus rubra*, *Quercus alba*, *Quercus macrocarpa*, *Quercus ellipsoidalis/Quercus velutina*) by superimposing the importance values (symbolic representation) for each species on the original ordination diagram (separate diagram for each tree species). The overlay diagrams facilitated our interpretation of gradients in plant species composition among the study sites.

We also calculated importance values for woody plant species in the subcanopy and shrub layers at each site, respectively, and analyzed these separately using DCA. Then, we calculated Pearson correlation coefficients for all pairs of first axis DCA scores (canopy, subcanopy and shrub layers) to test for collinearity.

Ultimately, we used first axis scores obtained from DCA of canopy species as an independent variable representing canopy composition (CANCOMP) in later analyses of bird-habitat relationships.

Landscape Parameters

We characterized the landscape in the vicinity of each study site using a GIS landuse coverage (raster) classified from recent (1992) satellite imagery (Thematic Mapper, 30 m resolution). First, we created an arc coverage of site boundaries by digitizing the site political boundaries as marked on USGS 7.5 minute quadrangles. Next, we used the Buffer command in ArcInfo to create an additional arc coverage representing a 1-km extension of the original site boundaries. Finally, we used the Clip command in ArcInfo to extract portions of the landuse coverage corresponding to the 1-km extension of site boundaries.

Using the Fragstats program (McGarigal and Marks, 1994), we measured four landscape indices characterizing the forest cover in the vicinity of each site. These were FOREST (total forest area (ha)); CORE (total forest area (ha) ≥ 50 m from forest edge); INDEX (area-weighted mean shape index) and DISTANCE (mean distance (m) between forest patches). The shape index for a given forest patch equals 1 for square patches and increases in value as patches become more irregular in shape (see McGarigal and Marks (1994) for formula). By using the area-weighted mean value of this index to characterize forest shape in the vicinity of our study sites, we assumed that the influence of forest patch shape on birds is weighted by patch area.

We tested for collinearity among the above variables by calculating Pearson correlation coefficients for each pair. Upon discovering high correlation between some variables, we used principal component analysis (PCA) to reduce the original set of variables to a smaller set of uncorrelated variables.

Regression Analyses of Landscape-Habitat Relationships

We tested for the influence of six independent variables on avian abundance and species richness using stepwise regression analyses with selection criterion $\alpha \leq .10$. Three of the independent variables were derived from vegetation data: TREECOV and SHRUBCOV (forest structure, derived from PCA analysis) and CANCOMP (canopy composition, derived from DCA axis 1). The other three independent variables were derived from PCA analysis of Fragstats indices characterizing the forest cover within 1-km of political site boundaries: AREA, DIST and SHAPE. Detailed descriptions of all independent variables appear in the Results.

RESULTS

Bird Community Composition

A list of all birds detected (inside the 50 m radius census circle) at least ten times during field work over the two years appears in Table 1. We present the total number of detections (inside the 50 m radius circle) for each bird species as well as its migratory status, preferred nest substrate, level of management concern and degree of area sensitivity as given in Best *et al.* (1996), Thompson *et al.* (1993) and Harrison (1975).

A complete list of all bird species encountered during field work for this study appears in Hemesath and Norris (1998).

Vegetation Variables

High correlation (r = 0.98) was discovered between CANCOV and SUBCOV (Table 2). Subsequent principal component analysis reduced the original three forest structure variables to two uncorrelated principal component variables which we refer to as TREECOV and SHRUBCOV (Table 3). Forests with high values for TREECOV have high canopy and subcanopy cover; high values for SHRUBCOV indicate forests with well developed shrub layers.

An ordination diagram of study sites appears in Fig. 2, based on detrended correspondence analysis (DCA) of importance values for canopy tree species. The eigenvalues associated with the first two DCA axes are 0.30 and 0.12, respectively. Although these eigenvalues do not represent the actual proportion of variance explained by their associated axes due to processes underlying DCA, they do indicate the relative strength of each axis (McCune and Medford, 1995). Clearly, much of the variation among forest study sites is explained by DCA axis one.

We interpret the first axis as a vegetation composition gradient. Highly mesic forests in northeast Iowa are dominated by sugar maple and basswood (Cahayla-Wynne and Glenn-Lewin, 1978). Overlay diagrams of importance values for sugar maple (Fig. 3a) and basswood (Fig. 3b) indicate that these tree species are most dominant in forests with low (0-50) first axis scores. Similarly, red oak and white oak are dominant in moderately mesic and dry forests in northeast Iowa (Cahayla-Wynne and Glenn-Lewin, 1978). The overlay diagrams for these species (Fig. 3c, 3d) indicate that they are most dominant in forests with intermediate (40-150) first axis scores. Although Cahayla-Wynne and Glenn-Lewin (1978) do not mention xeric forests dominated by bur, black (*Quercus velutina*) and/or northern pin oak, Curtis (1959) refers to such forests as the "dry segment" of oak forests occurring in nearby southern Wisconsin. Overlay diagrams for bur oak (Fig. 3e) and northern pin oak/black oak (Fig. 3f) indicate that study sites dominated by these tree species have the highest (140-220) first axis scores.

First axis scores obtained from DCA of importance values for canopy species were used as an independent variable (CANCOMP) in subsequent regression analyses of bird-habitat relationships. Note that we also conducted DCA analyses of importance values for subcanopy species and shrub species. However, first axis scores derived from analyses of canopy, subcanopy and shrub layers, respectively, are highly correlated ($r > 0.60$ for all possible pairs). Therefore, we excluded the DCA scores from subcanopy and shrub layers from later regression analyses.

Landscape Variables

High correlation (r = 0.98) was discovered between FOREST and CORE in the 1 km buffer coverages (Table 4). Subsequent principal analysis reduced the original four landscape variables to three uncorrelated variables: AREA, DIST and SHAPE (Table 5). Landscapes with high values for AREA have large amounts of forest cover and core area. DIST represents forest patch distance; high values for this variable indicate landscapes with widely spaced forest patches. Finally, SHAPE represents forest patch shape. High values for SHAPE are associated with landscapes in which forest patches are irregularly shaped.

Correlation Analysis of Independent Variables

Of the 15 possible variable pairings among independent variables, three (20%) significant correlations were detected (Table 6). Two of these relationships involved CANCOMP, which was correlated with TREECOV(-) and SHRUBCOV. In other words, forests dominated by bur, black and northern pin oak tend to have poor overstory differentiation and well developed shrub layers. We acknowledge that the inclusion of these correlated variables in subsequent regression analyses is undesirable and violates the assumption of non-collinearity for independent variables. Nevertheless, given the inherent non-independence among habitat characteristics in vegetation communities, we find this approach unavoidable.

Regression Analyses

Results of all stepwise regression analyses appear in Tables 7 (abundance) and 8 (species richness).

Abundance. The abundances of eight (80%) bird groups were correlated with one or more vegetation variables in 1995 and/or 1996 (Table 7). Five bird groups were more abundant in mesic forests (CANCOMP(-)) and two bird groups were more abundant in xeric forests (CANCOMP(+)) during one year or the other. Significantly, no individual relationships between bird abundance and vegetation variable(s) were detected during both 1995 and 1996.

The abundances of six (60%) bird groups were correlated with at least one landscape variable in 1995 and/or 1996 (Table 7). Cavity nesting birds were more abundant in small forests (AREA(-)) during both years of this study. Likewise, ground nesting birds were more abundant in large, compact forests (AREA(+), SHAPE(-)) in 1995 and 1996. All other relationships were detected for only one year.

Species Richness. The species richnesses of seven (70%) bird groups were influenced by one or more vegetation variables in 1995 and/or 1996. The species richnesses of neotropical migrants, tree nesting birds, high management concern species and area sensitive birds were higher in mesic forests (CANCOMP(-)) in 1995 (but not in 1996). Both cavity nesting birds and ground nesting birds had higher species richness in forests with dense shrub layers (SHRUBCOV(+)) in 1995 and 1996.

Landscape variables influenced the species richness of six (60%) bird groups during at least one year. All of these relationships involved either forest area (AREA) and distance between forest patches (DIST); forest shape (SHAPE) did not influence the species richness of any bird group. Significantly, the species richness of high management concern species was correlated with large forests (AREA(+)) during both years of this study.

DISCUSSION

Habitat Relationships

Clearly, vegetation characteristics influence the abundance and species richness of northeast Iowa forest birds (Tables 7, 8). Likewise, forest bird abundance in adjacent states (Wisconsin, Illinois) is often correlated with vegetation characteristics (Ambuel and Temple, 1983; Blake and Karr, 1987). As for relationships with species richness, most previous studies have focused on *overall species richness in a forest patch* rather than *mean number of bird species detected per census point at each site*, as we have done. Therefore, it is difficult to make meaningful comparisons with other studies.

Six bird groups (60% of total) were more abundant and/or more species rich in mesic forests (CANCOMP(-)) for at least one year of this study, including total birds, neotropical migrants, short-distance migrants, tree nesting birds, high management concern species and area sensitive birds. Conversely, two bird groups (i.e., permanent residents, ground nesting birds) were associated with xeric forests (CANCOMP(+)) during this study.

Bond (1957) also discovered a shift in bird species composition between xeric forests (dominated by *Quercus velutina*) and other, more mesic forests (dominated *by Acer saccharum*) in nearby southern Wisconsin, thus lending support to our findings in northeast Iowa. He reported that shrub nesters and plant-eating bird species were most common in xeric forests and that foliage gleaners, sapling nesters and ground-feeding insectivorous birds were more common in mesic stands. Although Bond's results do not directly confirm our own findings, results from both studies suggest that bird community composition in this region is influenced by vegetation composition.

Of all the relationships with vegetation variables revealed in our study, only two were detected in both 1995 and 1996 (Table 8). These were correlations between the species richness of short-distance migrants and ground nesting birds, respectively, with SHRUBCOV(+) (i.e., forests with dense shrub layers). The latter result is not surprising because many ground nesting birds, including the ovenbird and the Eastern towhee, usually construct their nests where low vegetation is present (Harrison, 1975). All other specific relationships with vegetation variables (including all correlations with CANCOMP) were detected during only one year of this study and are hence tentative.

Annual variation in habitat use by birds is well documented elsewhere. For instance, Szaro *et al.* (1990) reported annual differences in foraging patterns (tree species selection, substrate use, etc.) of several passerines in ponderosa pine (*Pinus ponderosa*) forests. Likewise, Hejl and Verner (1990) describe differential use of foraging substrate by two songbird species between years in oak (*Quercus* sp.) and pine (*Pinus* sp.) forests. Our own results may likewise reflect real variation in habitat use by forest birds in northeast Iowa between 1995 and 1996.

Landscape Relationships

Landscape effects on forest bird communities are well documented for the Midwest (Faaborg *et al.*, 1995). Thus, our finding that landscape characteristics influence forest birds in northeast Iowa is not unexpected.

One finding that high management concern bird species (i.e., PIF $\geq$ 3.0) have higher species richness in regions with large amounts of forest cover (AREA(+)) has important forest management implications. The above result is not unexpected because most (86%) of the fourteen bird species in this management assemblage are area-sensitive elsewhere (Table 1). Many previous studies have reported a positive correlation between overall bird species richness (i.e., total number of bird species in a forest patch) and forest area. Our results make an even stronger statement about the importance of large forests to high priority birds because our measure of species richness (i.e., the mean number of bird species detected per census point at each site) is more conservative than traditional measures. Specifically, our measure of species richness is influenced much less by chance observations of birds than are typical measures of species richness which increment a full unit with each encounter of a new species.

Ground nesting birds were also more abundant in landscapes with large amounts of forest cover (AREA(+)) (Table 7). The two most frequently detected ground nesting birds in this study, the ovenbird (*Seiurus aurocapillus*) and the Eastern towhee (*Pipilio erythrophthalamus*), have elsewhere exhibited positive and negative area sensitivity, respectively (Table 1). The much greater abundance of ovenbirds relative to all other ground nesting birds is probably responsible for the overall positive relationship between the abundance of ground nesting birds and total forest cover. Ground nesting bird abundance was also influenced by forest patch shape (Table 7); abundance of these birds was higher in compact, regularly shaped forest patches (SHAPE(-)).

Cavity nesting birds were most abundant in landscapes with low forest cover (AREA (-)) in 1995 and 1996 (Table 7). This result is surprising because most (64%) of the cavity nesting bird species encountered in this study exhibit positive area sensitivity elsewhere (Table 1). In fact, no cavity nesting bird detected by us in this study was reported to exhibit negative area sensitivity by Best *et al.* (1986). Once again we are reminded that area sensitivity demonstrated for birds in one region is no guarantee of similar behavior elsewhere (Faaborg *et al.*, 1995).

All other relationships with landscape parameters were detected for a single year of this study and hence are considered tentative.

Conclusions

The general results of this study concur with those reported in adjacent states; namely, vegetation and habitat characteristics influence bird community composition in the Central Hardwoods. These results are perhaps more general than those reported previously from this region because we analyzed for habitat and landscape relationships across a broader range of forest types (mature forests, disturbed forests) than were considered in most previous studies. We discovered a general shift in bird composition across a vegetation composition gradient spanning xeric (i.e., dominated by bur oak, black oak and northern Hill's oak) through mesic (dominated by sugar maple and American basswood) forests. We found evidence to suggest that several bird groups likely to be of concern to forest managers, including neotropical migrants and high management concern species (PIF $\geq$ 3), tend to be more abundant and/or species rich in mesic forests. Our most important finding is that high priority birds have their highest species richness (mean number of species detected per census point at each site) in large forest patches.

We agree with many other researchers that analyses of bird-habitat relationships are stronger when detected during multiple years of a study (Wiens, 1981; Blake and Karr, 1987; Schooley, 1994). Hence, many of the specific results reported in this paper are tentative pending additional testing. Long-term studies of bird communities, such as those conducted over several decades (e.g., Holmes, 1990; Holmes et al., 1979), are necessary for strong demonstration of habitat and landscape relationships.

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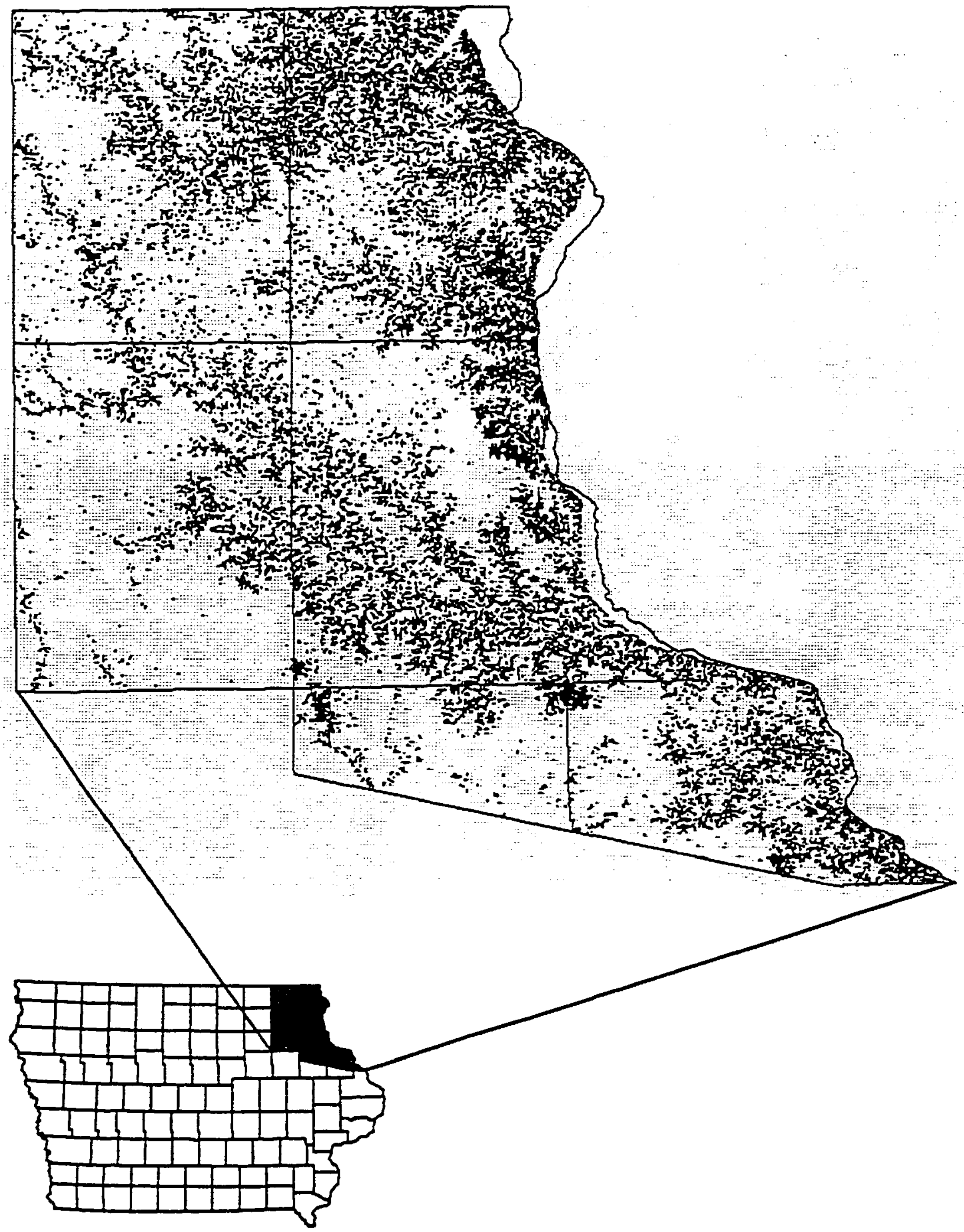


Fig 1. Current extent of tree cover in northeast Iowa. Total tree cover (19%) was calculated from a GIS raster coverage of landuse types classified from recent (1992) thematic mapper satellite imagery (30-m resolution).

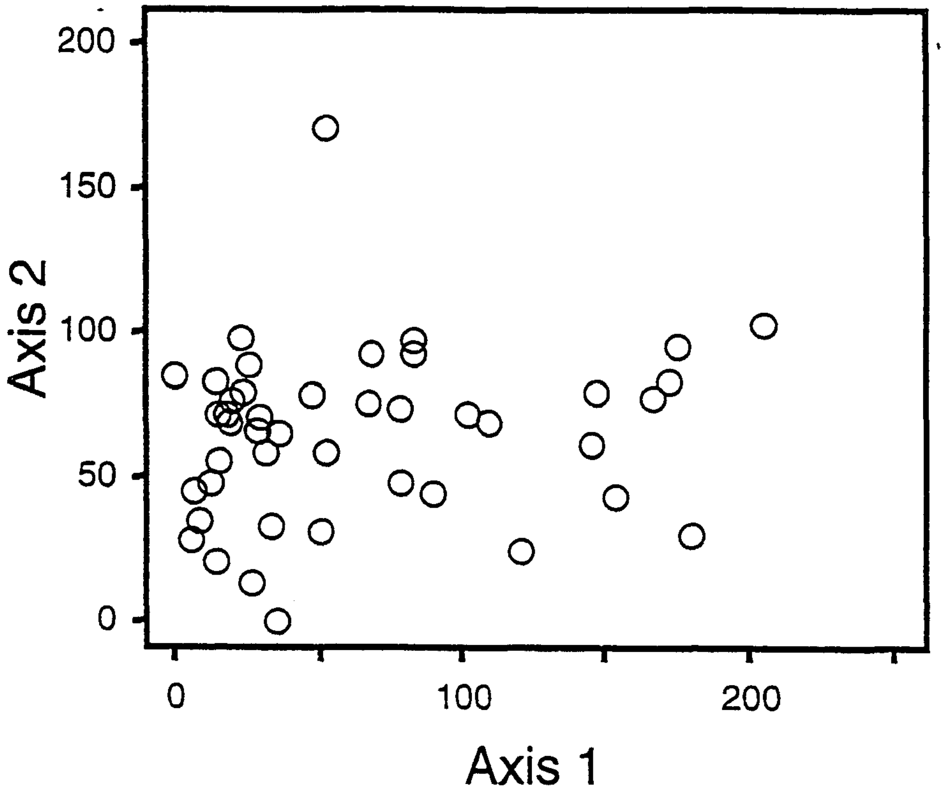


Figure 2. Ordination diagram for 44 study sites plotted along first two DCA (detrended correlation analysis) axes. DCA was conducted using importance values (i.e., (relative dominance + relative frequency) X 100) for canopy tree species at each site. Eigenvalues were $\lambda = 0.30$ for the first axis and $\lambda = 0.12$ for the second axis.

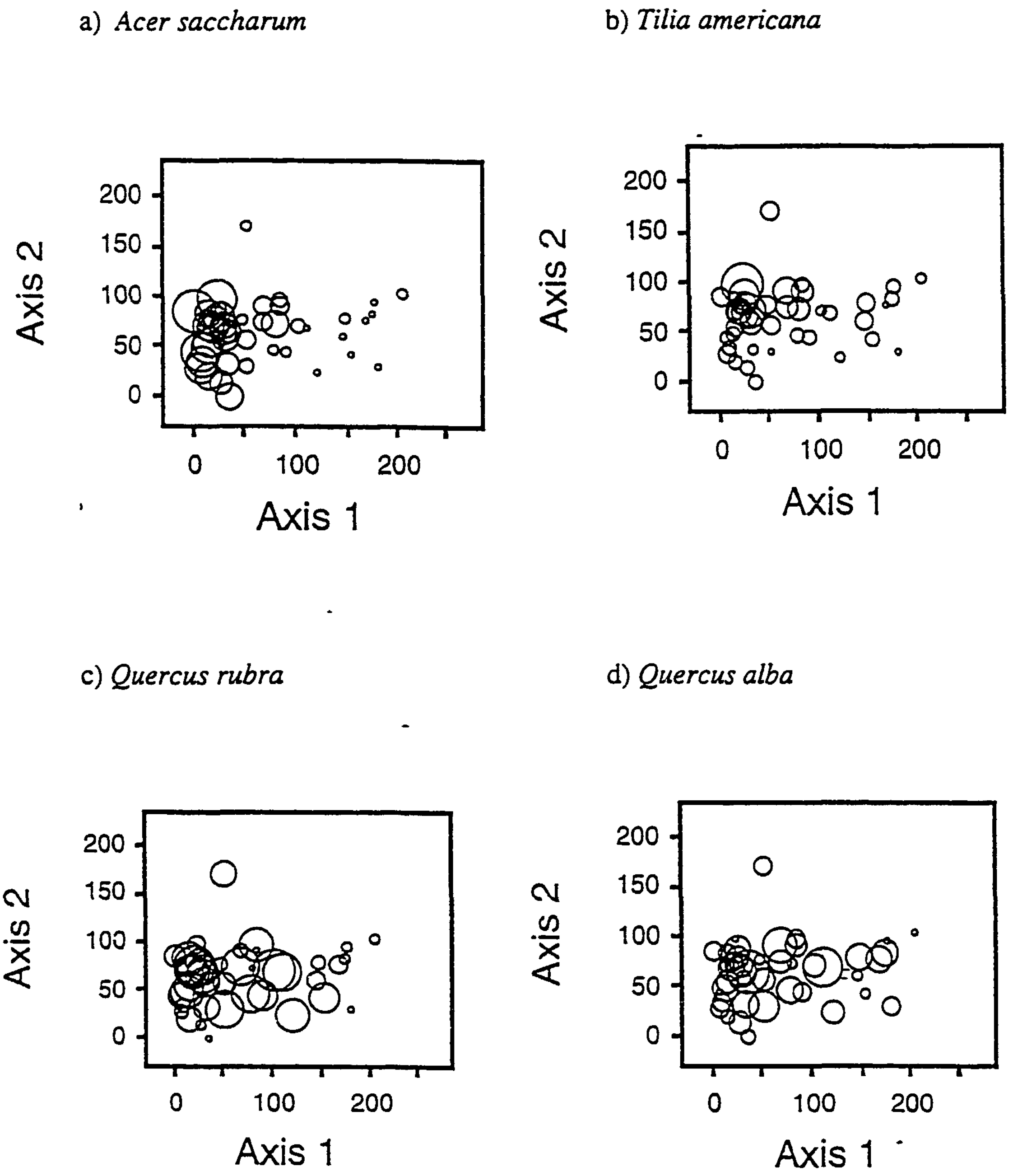
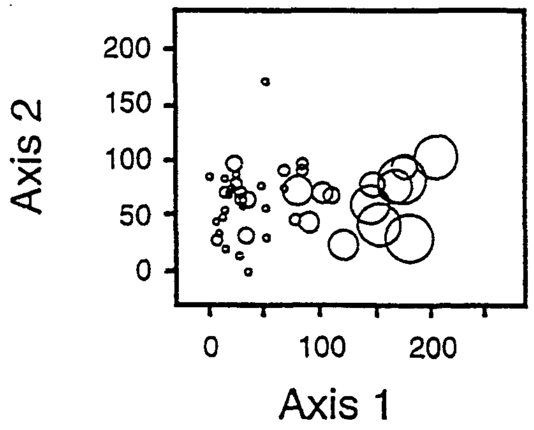


Figure 3. Overlay of importance values for six common tree species (a: *Acer saccharum*; b: *Tilia americana*; c: *Quercus rubra*; d: *Quercus alba*; e: *Quercus macrocarpa*; f: *Quercus ellipsoidalis/velutina*) on ordination diagram of 44 study sites. Importance values for each tree species are proportional to the size of the plotting symbol in each diagram.

e) *Quercus macrocarpa*



f) *Quercus ellipsoidalis/velutina*

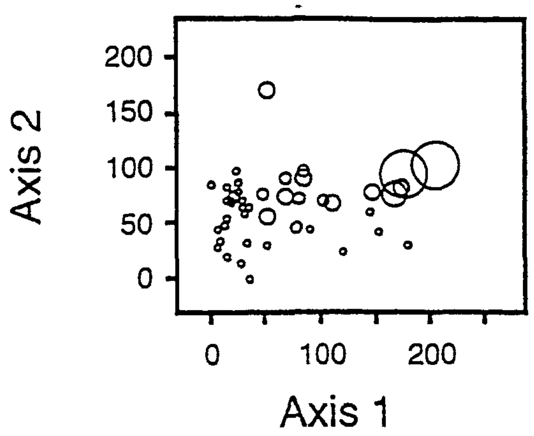


Figure 3. (continued)

Table 1. Bird species detected during point counts in 44 study sites in northeast Iowa forests (1995-1996). N = number of observations (inside a 50 m radius circle) during both years. Migratory Status: neo = neotropical; per = permanent resident; sho = short-distance migrant. Nest Substrate: c = cavity; g = ground; s = shrub; t = tree; b = streambanks; bu = man-made structures. PIF = Partner's in Flight prioritization index (index ranges from 0 to 5; higher values indicate higher concern). Area Sensitivity: ++ = consistently positive area sensitive; + = primarily positive area sensitivity but some studies detected none; (+) = primarily no area sensitivity but some studies detected positive area sensitivity; 0 = consistently no area sensitivity; (-) = primarily no area sensitivity but some studies detected negative area sensitivity; - = primarily negative area sensitivity but some studies detected none; (?) = area sensitivity unknown because of contradictory results; ? = area sensitivity unknown because it has not been studied. Migratory status, nest substrate, PIF indices values and Area Sensitivity indices derived from Best *et al.* (1996), Thompson *et al.* (1993) and Harrison (1975). Birds detected fewer than ten times over the two years are not listed.

Species	N	MigStat	Nest	PIF	AreaSens
Brown-headed cowbird (*Molothrus ater*)	628	sho	--	--	(+)
Blue-gray gnatcatcher (*Polioptila caerulea*)	556	neo	t	2.43	++
Eastern wood-pewee (*Contopus virens*)	484	neo	t	3.29	+
Red-eyed vireo (*Vireo olivaceus*)	482	neo	t	2.14	+
American redstart (*Setophaga ruticilla*)	373	neo	s	2.86	+
House wren (*Troglodytes aedon*)	317	neo	c	1.57	(?)
Ovenbird (*Seiurus aurocapillus*)	311	neo	g	3.14	++
Indigo bunting (*Passerina cyanea*)	292	neo	s	2.86	(-)
White-breasted nuthatch (*Sitta carolinensis*)	285	per	c	--	+
Northern cardinal (*Cardinalis cardinalis*)	255	per	s	--	(-)
Great crested flycatcher (*Myiarchus crinitus*)	250	neo	c	3.29	+
Blue jay (*Cyanocitta cristata*)	242	per	t	--	(+)
Gray catbird (*Dumetella carolinensis*)	233	neo	s	2.86	(-)
Black-capped chickadee (*Poecile atricapillus*)	205	per	c	--	(+)
Red-bellied woodpecker (*Melanerpes carolinus*)	183	per	c	--	+
Hairy/downy woodpecker (*Picoides villosus/pubescens*)	165	per	c	--	+
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	163	neo	s	3.14	+
Yellow-throated vireo (*Vireo flavifrons*)	163	neo	t	3.00	+
Scarlet tanager (*Piranga olivacea*)	153	neo	t	3.00	++

Table 1 (continued)

Species	N	MigStat	Nest	PIF	AreaSens
American goldfinch (*Carduelis tristis*)	142	sho	s	--	(?)
American robin (*Turdus migratorius*)	141	sho	t	--	(-)
Acadian flycatcher (*Empidonax virescens*)	129	neo	t	3.43	++
Eastern towhee (*Pipilio erythrophthalamus*)	112	sho	g	--	-
Baltimore oriole (*Icterus galbula*)	102	neo	t	2.86	(+)
Tufted titmouse (*Baeolophus bicolor*)	97	per	c	--	+
Wood thrush (*Hylocichla mustelina*)	73	neo	s	3.57	++
American crow (*Corvus brachyrhynchos*)	70	per	t	--	(+)
Chipping sparrow (*Spizella passerina*)	69	neo	s	1.86	(-)
Red-winged blackbird (*Agelaius phoeniceus*)	48	sho	g	--	(-)
Common yellowthroat (*Geothlypis trichas*)	47	neo	g	2.29	(?)
Yellow warbler (*Dendroica petechia*)	47	neo	s	1.57	(+)
Yellow-bellied sapsucker (*Sphyrapicus varius*)	37	sho	c	--	+
Cerulean warbler (*Dendroica cerulea*)	36	neo	t	4.29	++
Ruby-throated hummingbird (*Archilochus colubris*)	36	neo	t	2.57	(+)
Song sparrow (*Melospiza melodia*)	35	sho	s	--	(?)
Blue-winged warbler (*Vermivora pinus*)	33	neo	g	3.57	?
Red-headed woodpecker (*Melanerpes erythrocephalus*)	32	sho	c	--	(+)
Pileated woodpecker (*Dryocopus pileatus*)	31	per	c	--	+
Common grackle (*Quiscalus quiscula*)	27	sho	t	--	0
Least flycatcher (*Empidonax minimus*)	25	neo	t	2.71	++
Field sparrow (*Spizella pusilla*)	23	sho	g	--	(+)
Warbling vireo (*Vireo gilvus*)	23	neo	t	2.57	+
Yellow-billed cuckoo (*Coccyzus americanus*)	22	neo	s	3.29	+
Cedar waxwing (*Bombycilla cedrorum*)	21	sho	t	--	(+)
Eastern phoebe (*Sayornis phoebe*)	21	sho	b	--	+
Northern flicker (*Colaptes auratus*)	19	sho	c	--	(+)
Louisiana waterthrush (*Seiurus motacilla*)	17	neo	b	3.00	++
Veery (*Catharus fuscescens*)	17	neo	g	3.29	++

Table 1. (continued)

Species	N	MigStat	Nest	PIF	AreaSens
No. rough winged swallow (*Stelgidopteryx serripennis*)	13	neo	b	2.14	?
Brown thrasher (*Toxostoma rufum*)	12	sho	s	--	(?)
Chestnut sided warbler (*Dendroica pensylvanica*)	12	neo	s	3.57	?
Mourning Dove (*Zenaida macroura*)	11	sho	t	--	(?)

Table 2. Correlation matrix for mean values of forest structure variables (n = 44 sites). Values represent Pearson correlation coefficients. CANCOV = % canopy cover; SUBCOV = % subcanopy cover; SHRCOV = % shrub cover. ** indicates $p < 0.01$.

	CANCOV	SUBCOV	SHRCOV
CANCOV			
SUBCOV	0.52**		
SHRCOV	-0.02	0.10	

Table 3. Eigenvectors and eigenvalues for principal component analysis of mean values for three forest structure variables. CANCOV = % canopy cover; SUBCOV = % subcanopy cover; SHRCOV = % shrub cover (raw data). As an aid to understanding, the first two principal components have been renamed TREECOV and SHRUBCOV, respectively.

	Principal Components	
	PCA1 (TREECOV)	PCA2 (SHRUBCOV)
Forest Structure Variables		
CANCOV	0.70	-0.18
SUBCOV	0.71	0.03
SHRCOV	0.11	0.98
Eigenvalue	1.53	1.01
Variance Explained (%)	0.51	0.34
Cumulative Variance Explained	0.51	0.84

Table 4. Correlation matrix for landscape variables obtained from application of FRAGSTATS software on landuse (GIS) coverages of all (n = 44) study sites. Values represent Pearson correlation coefficients. Site coverages included all land within a 1-km extension of site boundaries. "Forest" was the land use class of interest. FOREST = total forest area (ha); CORE = total core area (all forest area (ha) at least 50 m from non-forest habitat); INDEX = area-weighted mean shape index (index for each patch = 1 when patch is square; > 1 for increasingly irregular shapes); DISTANCE = mean distance (m) between forest patches. '*' indicates $p \leq 0.05$; '**' indicates $p \leq 0.01$.

	FOREST	CORE	INDEX	DISTANCE
FOREST				
CORE	0.97**			
INDEX	0.31*	0.19		
DISTANCE	-0.10	-0.05	0.00	

Table 5. Eigenvectors and eigenvalues for principal component analysis of four landscape variables: FOREST, CORE, INDEX and DISTANCE (described in text). Analyses included all land within a 1 km extension of site boundaries. As an aid to understanding, the first three principal components have been renamed AREA, DIST and SHAPE, respectively.

	Principal Components		
	PCA1 (AREA)	PCA2 (DIST)	PCA3 (SHAPE)
Landscape Variables			
FOREST	0.68	-0.01	-0.15
CORE	0.66	0.01	-0.28
INDEX	0.29	0:27	0.91
DISTANCE	-0.09	0.96	-0.26
Eigenvalue	2.09	1.00	0.89
Variance Explained (%)	0.52	0.25	0.22
Cumulative Variance Explained	0.52	0.77	1.00

Table 6. Correlation matrices for six variables describing landscape, forest structure and forest composition attributes of 44 study sites. Values are Pearson correlation coefficients. All variables described in text. * indicates $p \leq 0.05$.

	AREA	DIST	SHAPE	TREECOV	SHRUBCOV	CANCOMP
AREA						
DIST	0.00					
SHAPE	0.00	0.00				
TREECOV	0.25	0.03	-0.01			
SHRUBCOV	-0.07	-0.28	0.30*	0.00		
CANCOMP	-0.13	-0.25	0.21	-0.32*	0.38*	

Table 7. Stepwise regression analyses of bird abundance on vegetation (TREECOV, SHRUBCOV, CANCOMP) and landscape (AREA, DIST, SHAPE) variables. Abundance is defined as the mean number of birds detected (inside 50 m radius circle) per bird census point at each study site (n = 44). Landscape variables were derived from FRAGSTATS analysis of landuse site coverages representing 1-km extensions of site boundaries. Descriptions of bird groups and all variables appear in text. Selection criterion for entry of variables into model: $\alpha \leq 10$. '*' indicates $p \leq .10$; '**' indicates $p \leq .05$; '***' indicates $p \leq .01$.

Bird Group	Model r^2	Vegetation Variables	Landscape Variables
Total Birds			
Total Birds (1995)	0.08	none	AREA(-)*
Total Birds (1996)	0.07	CANCOMP(-)*	none
Migratory Assemblages			
Neotropical Migrants (1995)	--	none	none
Neotropical Migrants (1996)	0.14	CANCOMP(-)**	none
Permanent Residents (1995)	0.17	none	AREA(-)*, DIST(-)**
Permanent Residents (1996)	0.08	CANCOMP*	none
Short-Distance Migrants (1995)	--	none	none
Short-Distance Migrants (1996)	0.08	CANCOMP(-)	none
Nest Substrate			
Cavity (1995)	0.21	none	AREA(-)**, DIST(-)**
Cavity (1996)	0.13	none	AREA(-)**
Ground (1995)	0.37	TREECOV*, CANCOMP**	AREA***, SHAPE(-)*
Ground (1996)	0.30	SHRUBCOV**	AREA**, SHAPE(-)**
Shrub (1995)	--	none	none
Shrub (1996)	--	none	none

Table 7. (continued)

Bird Group	Model r^2	Vegetation Variables	Landscape Variables
Nest Substrate			
Tree (1995)	--	none	none
Tree (1996)	0.12	CANCOMP(-)**	none
Conservation Priority (PIF ≥ 3.0)			
(1995)	--	none	none
(1996)	0.19	TREECOV*	SHAPE(-)**
Area Sensitive Birds			
(1995)	--	none	none
(1996)	0.22	CANCOMP(-)***	SHAPE(-)*

Table 8. Stepwise regression analyses of bird species richness on vegetation (TREECOV, SHRUBCOV, CANCOMP) and landscape (AREA, DIST, SHAPE) variables. Species richness is defined as the mean number of bird species detected per bird census point at each study site (n = 44). Landscape variables were derived from FRAGSTATS analysis of landuse site coverages representing 1-km extensions of site boundaries. Descriptions of bird groups and all variables appear in text. Selection criterion for entry of variables into model: $\alpha \leq 10$. '*' indicates $p \leq .10$; '**' indicates $p \leq .05$; '***' indicates $p \leq .01$.

Bird Group	Model r^2	Vegetation Variables	Landscape Variables
Total Birds			
Total Birds (1995)	--	none	none
Total Birds (1996)	0.08	none	AREA*
Migratory Assemblages			
Neotropical Migrants (1995)	0.18	CANCOMP(-)**	none
Neotropical Migrants (1996)	0.26	none	AREA***, DIST**
Permanent Residents (1995)	0.08	none	DIST(-)*
Permanent Residents (1996)	0.07	none	none
Short-Distance Migrants (1995)	0.13	SHRUBCOV**	none
Short-Distance Migrants (1996)	0.20	SHRUBCOV***	none
Nest Substrate			
Cavity (1995)	--	none	none
Cavity (1996)	--	none	none
Ground (1995)	0.09	SHRUBCOV**	none
Ground (1996)	0.55	SHRUBCOV***, CANCOMP***	AREA***
Shrub (1995)	--	none	none
Shrub (1996)	--	none	none

Table 8. (continued)

Bird Group	Model r^2	Vegetation Variables	Landscape Variables
Nest Substrate			
Tree (1995)	0.08	CANCOMP(-)*	none
Tree (1996	--	none	none
Conservation Priority (PIF $\geq$ 3.0)			
(1995)	0.27	CANCOMP(-)**	AREA*, DIST*
(1996)	0.27	none	AREA***, DIST*
Area Sensitive Birds			
(1995)	0.19	CANCOMP(-)***	none
(1996)	0.35	none	AREA***, DIST***

CHAPTER 7. GENERAL CONCLUSIONS

There have been countless investigations of the habitat preferences of forest birds reported in the literature (Cody, 1985). Most of these are based on two or three years of field work due to funding constraints and academic pressure to publish results in a timely fashion. Nonetheless, most researchers hope to discover that the occurrence of some (or many) bird species can be predicted reasonably well from habitat and landscape characteristics of forest patches. Of course, these relationships gain strength if they can be demonstrated during multiple years of a study.

Those of us who conducted this study likewise had high aspirations of revealing strong habitat associations for birds residing in northeast Iowa forests. Noting that most other similar investigations in the Midwest have not included disturbed (logged/grazed) forests despite their frequent occurrence in this region, we asked the question: Do forest birds in northeast Iowa preferentially utilize (or avoid) disturbed forests relative to mature forests that have not been logged and/or pastured for at least 50 years? A related question involves the impact of forest succession of bird community composition: Does bird community composition shift between oak (*Quercus* sp.) dominated forests and more mesic maple (*Acer saccharum*) dominated forests? This latter question is of great interest given that oak-dominated forests in Iowa are probably in transition to dominance by sugar maple at this time (Jungst et al., 1998).

Our results shed some light on the first stated question above. We discovered (Tables 3, 4; Chapter 5) that undisturbed forests, such as those set aside in northeast Iowa as forest preserves, are attractive to a subset of bird species (all neotropical migrants) considered to be of high management concern by the U.S. Fish and Wildlife Service (Thompson et al., 1993). This same bird group also had higher species richness (mean number of bird species per census point at each site) in large forest tracts than in small forest patches. The above associations were demonstrated in both 1995 and 1996 and hence forest managers in northeast Iowa can confidentally assume that large tracts of undisturbed forest habitat will attact a greater variety of these bird species than recently disturbed and/or small forests. *In my view, this is the most significant result of this investigation.*

What is the mechanism of the above relationships? Most of the birds grouped together as "high management concern species" are known elsewhere to be area sensitive (Table 1; Chapter 5), so the correlation between their species richness and forest area is not surprising. Potential benefits of large forest sites to birds include higher nest success, increased food supply and (at least in some regions) decreased incidence of nest predation and parasitism (Faaborg et al., 1995; Robinson et al., 1995; Burke and Mol, 1998). We can only speculate why these birds are attracted to old growth forests because our analyses do not show strong relationships between the species richness of high management concern species and specific attributes of forest vegetation (Table 4; Chapter 5). Relative to disturbed forests, old-growth forests may possess particular woody plant species, structural characteristics or overall "gestalt" that are preferred by conservative bird species. Alternatively, old-growth forests may possess other features (soil, food availability, etc.) unrelated to vegetation that influence habitat selection by these birds.

With respect to the question: Do forest birds discriminate between oak- and maple-dominated forests; our results are inconclusive. We can report a general shift in bird community composition along a forest composition gradient spanning mesic (dominated by *Acer saccharum* and *Tilia americana*) and xeric forests (dominated by dry oak species: northern pin oak, *Quercus ellipsoidalis*; bur oak, *Quercus macrocarpa*; black oak, *Quercus velutina*) (Tables 7, 8; Chapter 6). Bond (1957) likewise reported that bird composition changed along a forest moisture gradient in nearby southern Wisconsin. In our study, many bird groups (including neotropical migrants and high management concern species) were more abundant and/or exhibited more species richness at the mesic end of this spectrum; however, *no single relationship involving associations with forest type was demonstrated for both 1995 and 1996*. Hence, all specific results are tentative.

From a forest management perspective, there is great interest in whether bird community composition is influenced by shifts in overstory tree dominance between sugar maple (mesic forests) and red/white oak (dry-mesic forests). Referring to Fig. 3 in Chapter 6, red oak and sugar maple are frequently co-dominant in our study sites. Given this significant overlap in the distributions of these two species, as well as the inconsistency between years of all correlations between bird abundance/species richness and forest type (Tables 7, 8; Chapter 6), we are unable to resolve this question.

Finally, this research provides a thorough documentation of bird community composition in northeast Iowa forests. We discovered that the abundance and species richness of birds is highly variable between years, with both being higher in 1995 than in 1996 (Table 2, Chapter 3). However, the overall rank order of bird species was stable from year to year, with little shift in the ranks of the most dominant bird species. Among the eight most frequently detected bird species during our study were seven neotropical migrants (Fig.

2; Chapter 3); however, the highest ranking bird during both 1995 and 1996 was a nest parasite, the brown-headed cowbird (*Molothrus ater*). If rates of nest parasitism are proportional to cowbird abundance, these results suggest that the nest success of host birds in northeast Iowa forests may be extremely low. Research is currently underway to determine rates of cowbird parasitism and nest success for birds in northeast Iowa forests (Knutson, pers. comm.)

The great variability demonstrated for many of the relationships revealed in this study demonstrates the need for long-term studies (e.g., Holmes, 1990; Holmes et al., 1979) to truly understand bird community dynamics and the strength of bird-habitat relationships in Midwestern forests.

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